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HEATING SYSTEM INSTALLED AT CHARLOTTESVILLE,  
VIRGINIA Final Report (Wilson-Hill  
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**DOE/NASA CONTRACTOR  
REPORT**

**DOE/NASA CR-161675**

**SOLAR SPACE AND WATER HEATING SYSTEM INSTALLED AT  
CHARLOTTESVILLE, VIRGINIA**

Prepared from documents furnished by

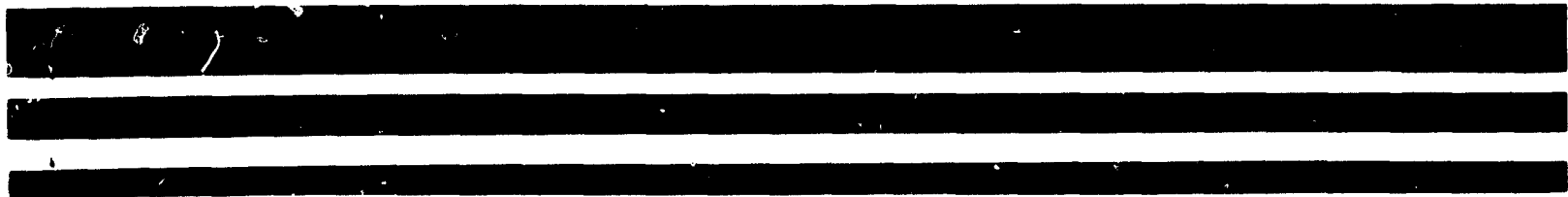
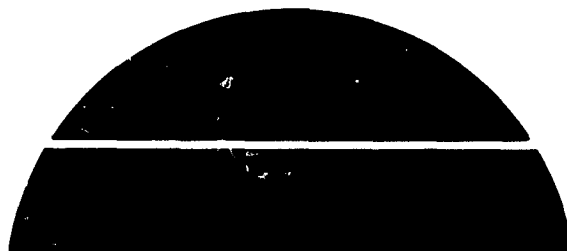
David C. Wilson Neuropsychiatric Hospital  
Charlottesville, Virginia 22901

Under DOE Contract EG-77-A-01-4095

Monitored by

National Aeronautics and Space Administration  
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy



**U.S. Department of Energy**



**Solar Energy**

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15. SUPPLEMENTARY NOTES This work was done under the technical management of Mr. Charles L. Greer, George C. Marshall Space Flight Center, Alabama 35812.			
16. ABSTRACT <p>This Document is the Final Report of the Solar Energy System located at David C. Wilson Neuropsychiatric Hospital, Charlottesville, Virginia. The solar system consists of 88 single glazed, Sunworks 'Solector' copper base plate collector modules; hot water coils in the hot air ducts; a Domestic Hot Water (DHW) preheat tank; a 3,000 gallon concrete urethane - insulated storage tank and other miscellaneous components.</p> <p>This report includes extracts from the site files, specifications, drawings, installation, operation and maintenance instructions.</p>			
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## SUMMARY

The David Wilson Hospital has 50 beds and provide patient care 24 hours a day. The solar system consists of 88 single glazed, selectively coated, copper base plate collector modules; hot water coils in the hot air ducts; A DHW preheat tank; a three thousand gallon concrete urethane-insulated storage tank and other miscellaneous components. The collectors are mounted on the roof in a sawtooth arrangement facing due south, inclined at an angle of  $53^{\circ}$  from the horizontal. The collectors are elevated above the storage tank so that any time the collector pump cuts off, a vacuum relief valve opens at the top of the collectors allowing air to enter and the water in the collector piping automatically flows back into the storage tank eliminating any need for freeze protection.

A request to the Department of Energy to enter into a cooperative agreement with the David Wilson Hospital for the development of a solar system at the Charlottesville facility was submitted in 1976. Approximately one year later, the hospital received one of ninety subsidized awards provided by the Federal Government during 1977.

Initially the system was to have used two stage heat pumps (air to air or solar heated water to air) and was to have been an instrumented site. Problems developed with the heat pump making it impractical to incorporate this approach into the solar design. As a consequence of the design change and other considerations such as cost, it was decided to also delete the instrumentation at the site.

The installation was further plagued by the necessity to reroof after part of the collector support structure was installed.

The system was completed and tested on December 8, 1979, by the contractor. The system was evaluated by MSFC personnel during the week of January 29, 1980. Some non-operational difficulties were noted during the system checkout; however, satisfactory adjustments, arrangements, evaluations and repairs had been accomplished at the hospital by March 18, 1980, at which time the system was deemed acceptable to the Department of Energy.

## SUMMARY OF PROJECT INFORMATION

### A. General Information

**Owner/Builder:**

David C. Wilson Neuropsychiatric  
Charlottesville, Virginia 22901

**Contractor:**

Owen and Mayes, Inc.  
Lynchburg, Virginia 24502

**Operational Date:**

March 18, 1980

**Building:**

Type - Hospital  
Area - 7,218 sq. ft.  
Location - Charlottesville, Virginia

### B. Meteorological Data

Latitude 38°N

**Climate Data**

	Winter	Summer
Average Temperature (°F)	- 40°	- 68°
Average Insolation (Ly/d)	- 200	- 450
Degree Days (heating)	- 4166	

## INTRODUCTION

David C. Wilson Neuropsychiatric Hospital is a fifty bed private psychiatric facility located in Charlottesville, Virginia. In 1976 the hospital made application to the Department of Energy for a Solar Energy Grant and was the recipient of one of ninety grants awarded in the nation in 1977. The combined space heating and domestic hot water preheat system is designed to provide 67 percent of the heating requirements and supply 71 percent of the heat for the DHW at the hospital.

The original specifications called for 101 solar collectors with two (2) five and one-half ton dual source heat pumps. The designers of the system were unable to locate a manufacturer that could fabricate the heat pumps and reduced the number of collectors to eighty-eight along with the water storage tank from five thousand gallons to three thousand gallons. It was then determined that the existing roof had to completely be replaced, however, the solar system support structure was designed to fit very close to the roof and would, therefore, prohibit access to the roof once the solar collectors and support structures were mounted. The height of the needed "built up roof" had to be graded and pitched to allow proper drainage of water from the roof but still fit beneath the solar framing that was now in place. The alternate problem was to avoid penetration of the new roof's membrane by the solar contractors during and after the construction of the roof. The final solution called for the simultaneous construction of the roof and solar project in fifteen foot sections. The work was tedious and the hospital experienced major leakage from the roof during the course of construction.

The project was completed and tested on December 8, 1979, with final inspection by a team of experts from the Department of Energy during January, 1980. The system has been operational since December, 1979, and no major problems with the roof or solar system has been encountered.

The hospital's experience in this matter would indicate that design features include an assessment of existing roof structures with a statement from the architects on the impact of a Solar System on existing roof structures along with additional long range planning that permits repair and/or replacement of roofing structures. In all probability, the current Solar System will have to be partially or totally dismantled when the useful life of the roof expires in fifteen to twenty years.

The solar collector system is comprised of 88 single glazed, Sunworks 'Solector' solar collectors. The collectors are mounted on the roof in a sawtooth arrangement facing due south inclined at an angle of  $53^{\circ}$ . They are arranged in 12 rows with 8 collectors in 8 rows and 6 collectors in 4 rows. Each row is piped in parallel, reverse return flow. All rows are sloped to the center line of the roof so that they drain back to the storage tank when the circulation pump stops. The collectors in the individual rows are connected with copper pipe couplings and are referred to as internally manifolded solar collectors.

The system utilizes inhibitors in the solar loop water to reduce corrosion problems. The domestic hot water preheating section of the system is protected by a double wall heat exchanger.

The drain back feature of the solar system is accomplished in part by the combination air vent/vacuum breaker assembly. This component is shown in detail on Sheet M-2 of the system drawings.

Flow control of solar collector circulating fluid is performed by the Bell & Gossett circuit setter devices. There is one circuit setter per row and it is located in the return pipe. The flow controller is an instrument that meters system working pressure as a function of flow in gallons per minute. The contractor has provided the differential pressure meter. In the eight 8 collector rows there will be a flow of 4 gallons per minute per row. The four 6 collector rows will have a flow rate of 3 gallons per minute each. The contractor has adjusted the circuit setters for correct flow, but periodic checks should be part of system maintenance procedures. The branch supply pipe to each solar collector row has a gate valve for collector row isolation. If a solar collector should have to be replaced, the solar system must first be in the drain-down mode.

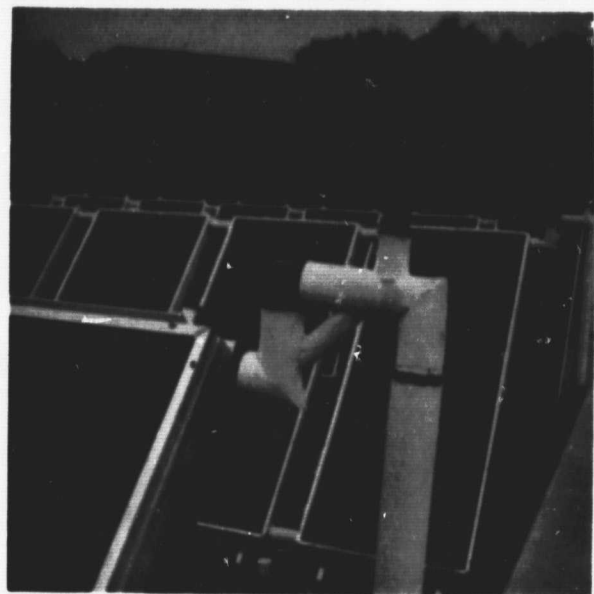
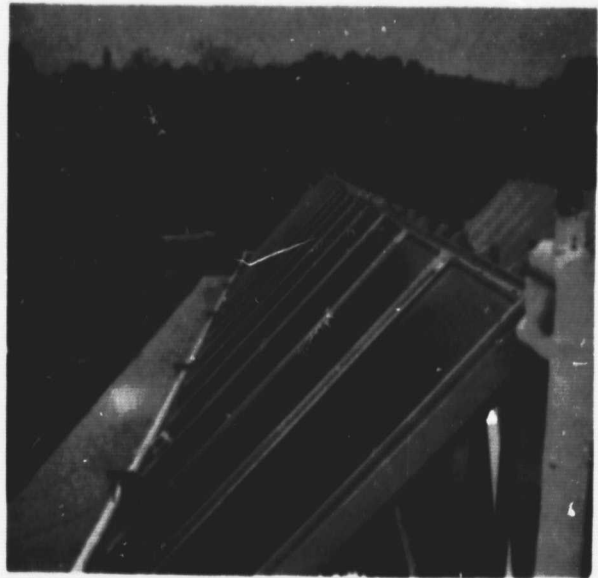


Hospital Entry

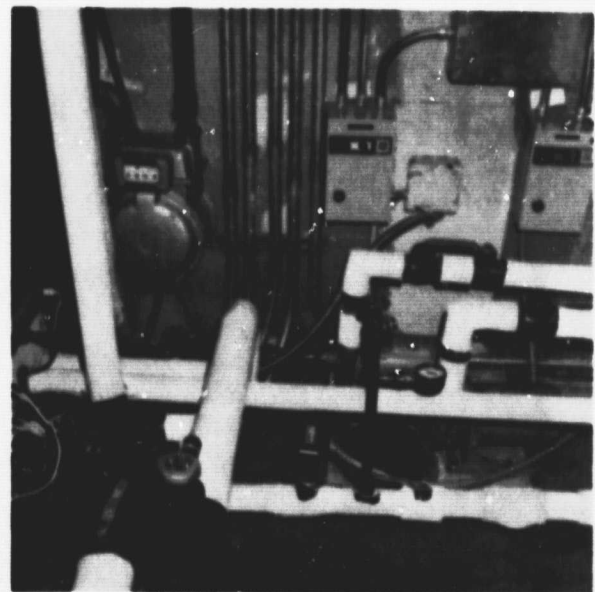
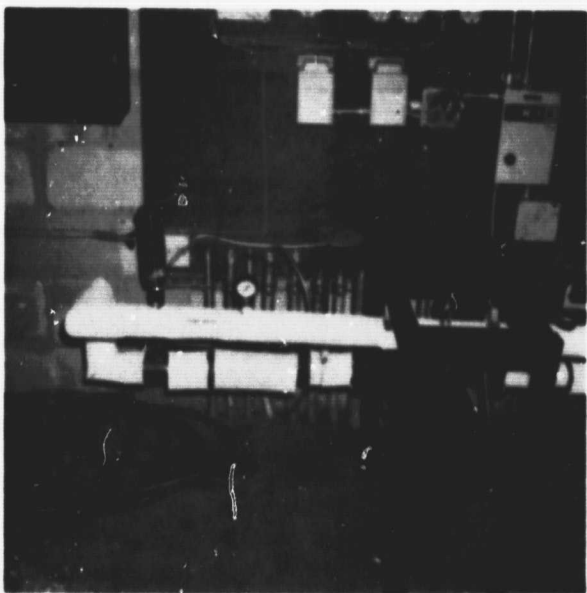
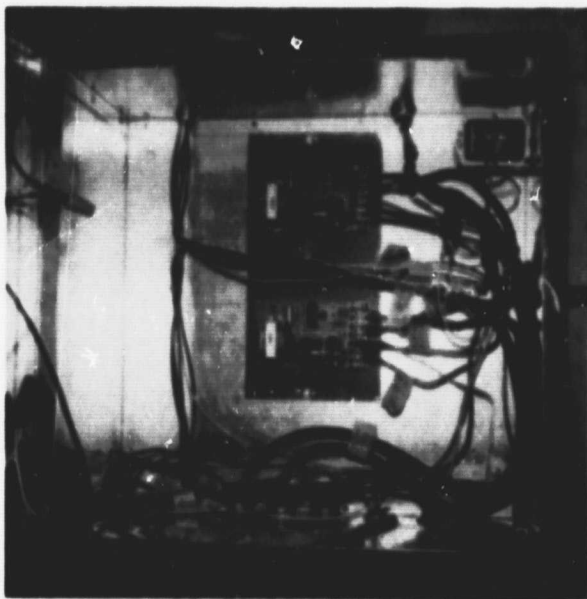


Food Preparation Centers

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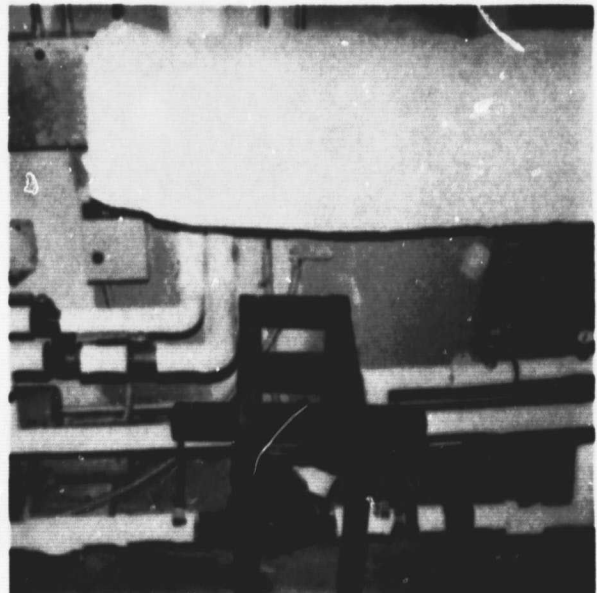
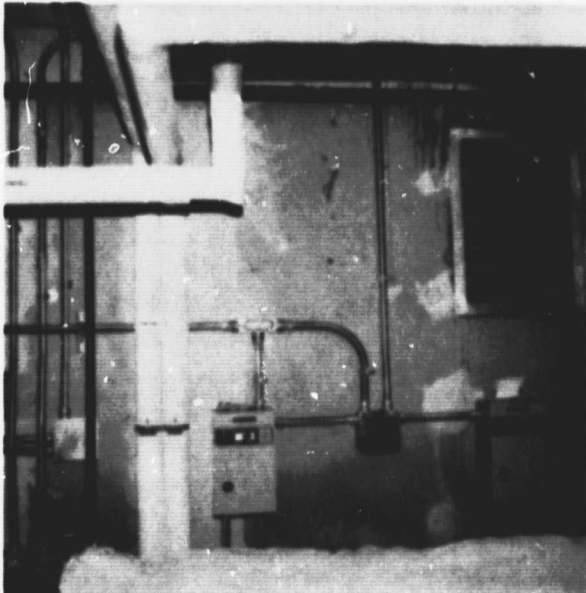
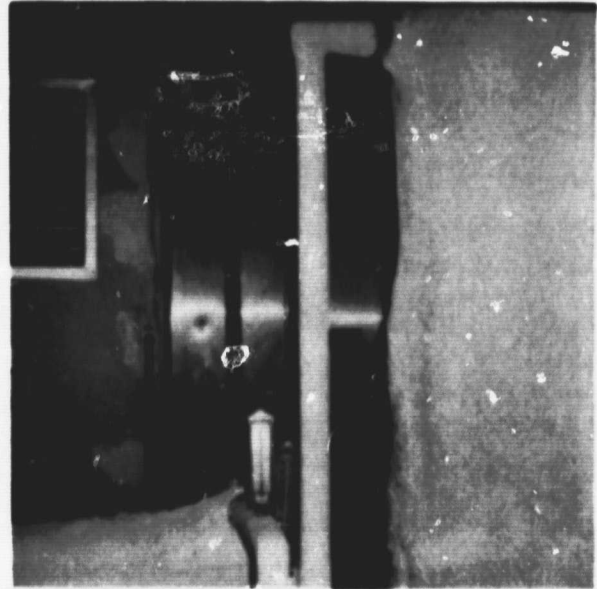
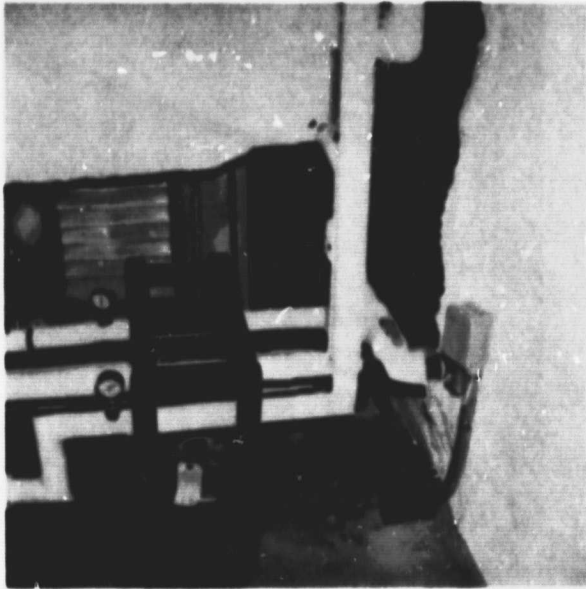
Various views of the roof mounted collectors. Two photographs on right show vacuum venting arrangement.



Mechanical room views showing pumps and control areas.

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Views showing double wall heat exchanger and the DHW storage tank.



# SYSTEM OPERATIONAL CHARACTERISTICS, TEST AND MAINTENANCE PROCEDURES

## I. SOLAR COLLECTORS

The solar collector system is comprised of 88 single glazed, Sunworks 'Solector' solar collectors. They are arranged 12 rows with 8 collectors in 8 rows and 6 collectors in 4 rows. Each row is piped in parallel, reverse return flow. All rows are sloped to the center line of the roof so that they drain back to the storage tank when the circulation pump stops. The collectors in the individual rows are connected with copper pipe couplings and are referred to as internally manifolded solar collectors.

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Collector removal begins with the sawing of the couplings that connect the defective collector to another. If the defective collector is on an end, the supply or return elbows can be un-sweated. The solar collectors have been piped together with 1" copper couplings that have no-stop. It is essential to have a no-stop coupling so that when a collector is to be installed, the couplings can freely slide from side to side. When removing the defective solar collector, be extremely cautious of any residual water that may drain out of the collector. If the sun is shining, this water will be extremely hot.

When scheduling period maintenance checks of the solar collectors, check the following items for proper system operation.

1. Inspect glazing of solar collectors for cracks. If a broken glazing is found, call the solar collector representative and arrange to have it replaced immediately. Maintenance personnel should have two replacement glazings in stock at all times.
2. Be absolutely certain that when all collectors are under circulation, the gate valves and circuit setters are open and/or adjusted appropriately. If any water is allowed to remain in the collectors during freezing weather, it will freeze in the collectors and cause permanent damage to the collector components.
3. Inspect the sensors on the solar collector stubs. They should be securely fastened and insulated. One collector sensor is currently being used while the other is there as a spare. The splice for the sensor leads to the control wiring and is inside the junction box which is located where the sensors are attached.
4. IMPORTANT! It is necessary to verify collector drain back every month. The following procedure will assure that all the water above the ground is draining into the storage tank when the collectors are in the drain mode.
  1. NOTE: Do not perform this test under full sunlight conditions or when the ambient air temperature is below 40°F. Late afternoon is a preferable time.
  2. The collector pump should not be running when this test is started. If the pump is running, then there is too much sunlight to begin the test. Wait until the collectors stop circulating entirely while the HOA Switch is in the AUTO mode. When the collectors have stopped circulating, which should be in the late afternoon, turn the HOA Switch to the OFF position. After placing the switch in the OFF position, note the time and observe the vacuum breaker that is several inches from the discharge side flange of the pump. The breaker should be down. Next, place the HOA Switch in the HAND position. The collector pump will start and fill the collector system. Allow 10 minutes for collector circulation,

place the HOA switch in the OFF position. Stand in close proximity to the previously mentioned vacuum breaker and wait for 15 minutes. After 15 minutes, the vacuum breaker will drop. The vacuum breaker cap is removable and should be taken off to facilitate observation. The 15 minute interval indicates that the system is draining as designed. If the drain interval increases by 3 or 4 minutes or more, then pipe corrosion could be present. It is very important that the solar storage water be monitored for the proper mixture ratio of corrosion inhibitor and for proper pH level. These checks should be done at least twice a year and can be done by maintenance personnel or by a water treatment company.

5. When the solar system begins to fill, the vacuum breakers will shut and a hissing sound can be heard from the air vent. In a few seconds the air vent will stop its noise. You can observe a stream of water by depressing the plunger in the top of the air vent. This test assures that the air vent is functioning properly.

## II. PUMPS

There are 5 pumps in the solar system. Their individual function and specifications are as follows:

### Solar Collector Circulation/Pump P-3

Bell & Gossett 2" A  
44 GPM @ 50' TDH 1-1/2 HP

### Solar Water to Heat Exchanger/Pump P-2

Bell & Gossett 1" AA  
6 GPM @ 20' TDH 1/4 HP

### Domestic Water to Heat Exchanger/Pump P-1

Bell & Gossett 1" AA  
13 GPM @ 25' TDH 1/4 HP

### Hydronic Coil Pump/York Unit/Pump P-4

Goulds 3642 1"  
15 GPM @ 20' TDH 1/3 HP

### Hydronic Coil Pump/Trane Unit/Pump P-5

Goulds 3642 1"  
15 GPM @ 18' TDH 1/3 HP

All pumps have foot valves at the end of their suction lines. This is to assure that there will always be prime in the pumps. As added protection to prevent pump damage from loss of prime, all pump circulating lines in the mechanical room have flow switches. There are 3 flow switches and each has a 20 second time delay. If the pump starts and the circulation lines are dry, the pump starter circuit is interrupted after 20 seconds of no flow conditions. When the flow switch discontinues pump operation, a signal will be heard in the nurses station. Loss of pump prime can be traced to leaks in the piping or the failure of a foot valve in the tank. See the separate enclosed procedure for restoring pump prime.

There is a procedure to be followed for returning the pumps to their normal operational mode after the flow switch has shut them down. After prime has been restored, turn the pump starter to the HAND mode and allow it to run for a few seconds. After circulation is established, rotate the HOA switch to the AUTO mode. The pump will now cycle automatically.

The strainers on the pump suction lines should be removed and cleaned as part of the general maintenance procedures.

Check all mechanical seals on pumps for leaks where the circulation systems are off. Also, check the motor and impeller shaft bearings by feel for overheating. An ammeter should be placed on the pump motor as a test when the motor housing feels hot. Any abnormal noise from the pump indicates a potential problem.

Please refer to the enclosed pump brochures for technical information.

## RESTORING PUMP PRIME

The following procedure explains how to prime pump lines. There are 4 pumps that have their suction lines in the solar tank. They are:

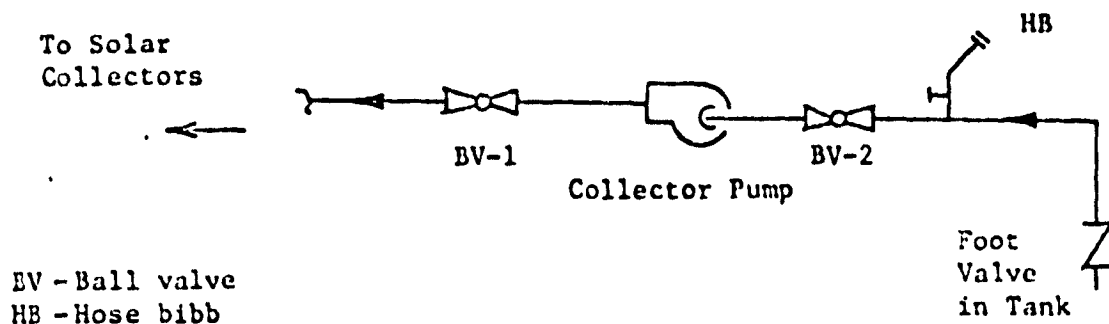
1. Solar collector circulation.
2. Solar water supply to the heat exchanger.
3. Solar water supply to the 2 hydronic coils - 2 pumps.

The 2 pumps for the hydronic coils operate independently of each other. However, they pull their water through a common suction header that branches once it enters the mechanical room. In this arrangement there is a single flow switch on the common suction header. If either of the pumps experience no flow conditions, the flow switch will discontinue the operation of both of them.

All three pump suction lines have foot valves at their termination point in the solar tank. Continuous loss of prime could be traced to a faulty foot valve. Check the plumbing in the mechanical room for leaks when investigating the causes of loss of prime.

When a flow switch discontinues pump operation, a signal in the nurses station will sound. The pump that has lost prime can be identified on the cover of the control box. If all pumps are in the automatic mode, then the running light for the appropriate pump will indicate which pump should have been running. The priming procedure begins as follows:

TYPICAL PUMP SCHEMATIC



1. Attach the garden hose in the mechanical room to the cold water hose bibb. Pinch the end of hose by bending it and turn on the water. Allow some water to flow so as to remove any air from the garden hose. Close the hose bibb on the pump piping and attach the garden hose to the hose bibb.

2. Be sure that BV 1 and BV 2 are shut. Next, open the valve on the hose bibb. After several seconds, close the hose bibb valve. Next, open BV 2. The water behind BV 2 will fill the pump. At this point, the air in the pump and the suction line will migrate to the upper part of the pump impeller case. On the upper part of the impeller case there is a hex nut. Back the nut away from the pump until there is a steady stream of water. Tighten the nut and open BV 1. The pump should be primed and the piping from the foot valve to the discharge side of the pump should be free from air.

### III. STORAGE

The storage for the system is a 3,000 gallon phenolic, epoxy lined tank. The tank exterior is sprayed with 4" of polyurethane foam and the foam is sealed with 40 mils of butyl rubber. The appropriate fill level is approximately 8"-12" from the bottom of the manhole. The level of the tank is monitored by an automatic level indicator. If the tank level falls below a preset level, the switch will activate an audio alarm located in the nurses station. The tank will have to be manually filled if make up water is required. Draining of the tank will be done by inserting a sump pump into the tank.

The storage water has been treated with a 1% solution of Sun Safe corrosion inhibitor. The ph level of the storage should be checked at least twice a year.

Located inside the concrete manhole is an aquastat and sensing bulb. Care must be taken when removing the bolted manhole lid so as to not disturb the sensing bulb capillary tube. The aquastat has a rain shield over it, but do not leave the vented manhole cover off for any extended period of time.

Do not park any vehicles over the storage tank. Excessive loading will cause compaction of the polyurethane foam.

### IV. DOMESTIC HOT WATER SYSTEM

The solar preheat domestic hot water system has 2 main components. One of these components is the Doucette double wall heat exchanger. It is suspended from the ceiling of the mechanical room and is encapsulated with 4" of polyurethane foam. The flow rates through the heat exchanger are as follows:

Solar Side - 6 GPM

Domestic Side - 13 GPM

The design of this heat exchanger is such that if a wall failure occurs on either the solar or potable side, the heat exchanger will drip at its vented end. If fluid is dripping from the heat exchanger, check all unions first. If the leaking does not cease, then turn the 2 domestic hot water system pumps off and immediately close all valves that allow domestic water to enter and leave the preheat tank. There is a third valve that will be opened so that normal domestic hot water production can resume. Refer to drawing M-2 for correct valve identification when this procedure is necessary.



The domestic hot water preheat tank is a 300 gallon galvanized tank. It is coated with 4" of polyurethane foam insulation. If the preheat tank must be drained, be certain that the floor drain is clear of all objects.

Periodically, inspect the sensor located at the stub for inlet water to the heat exchanger. It should be firmly attached and insulated.

#### V. HYDRONIC COILS

There are two hydronic coils that provide supplementary heat to the day room and to a zone that includes offices and meeting rooms. Heat in the day room is circulated by a fan inside the Trane rooftop unit. The other zone has its heat circulated by a fan inside the York rooftop unit. The enclosed hydronic coil sketch illustrates a detail that is applicable to both the York and Trane units. Both hydronic coils are Aerofin type 'CH' models. The coils are designed to circulate at 15 gallons per minute. Proper flow rates through the coils have been established by the engineer and contractor.

Periodic maintenance procedures should include the inspection of the filters in the return air ducts of these two coils. Frequent filter replacement will assure that the fan motor will not work at a static pressure in excess of its capacity.

#### VI. CONTROLS

The solar system controls are explained in the enclosed control system narrative. A control sequence is also enclosed. Any verifications of system performance should be done as instructed in the enclosed descriptions.

#### VII. GENERAL COMMENTS

A check list of possible problem areas is enclosed. Please refer to this list as a method of determining the origination of a problem.

The enclosed brochures will assist you in answering technical questions. If this instruction manual and its enclosures are insufficient in solving any problems with the solar system, contact the engineer immediately.

**Solar Collector Representative:**

Bryant Barnes  
Energy Systems, Inc.

**David C. Wilson Neuropsychiatric Hospital  
Department of Maintenance and Housekeeping**

**MAINTENANCE PROCEDURES FOR SOLAR SYSTEM**

The solar hot water and heat system has 88 single Sunworks "Solectors" solar collectors located on the roof. Also, there are five (5) pumps to the solar system located in the mechanical room off the service entrance, a 3,000 gallon storage tank located outside the service entrance in the ground, a Domestic hot water system located in the mechanical room and two Hydronic coils that provide supplementary heat located in duct work in the ceiling.

Preventative maintenance checks on the solar system will be done by David C. Wilson Hospital maintenance personnel and provide the following preventive maintenance checks on the equipment:

1. Check solar collectors for leaks or cracks.
2. Check gate valves and circuits setters.
3. Check solar collectors stubs.
4. Check solar collector drain back system.
5. Check solar system vaccum breakers.
6. Check pumps for overheating and leaks, also check and clean all strainers on the pump suction lines.
7. Check Domestic hot water system for sensor security, leaks, and insulation.
8. Check Hydronic heat coils in each unit. Clean each filter and exchange as needed.
9. Check storage tank for proper water level, proper Ph level, and proper solution mixture of corrosion inhibitor if water is added.

Upon completion of the monthly and biannual preventive maintenance checks, entry should be made in the preventive maintenance log book to show that this work has been done.

David C. Wilson Neuropsychiatric Hospital Department of Maintenance and Housekeeping  
Preventive Maintenance schedule for the Solar System and log sheet:

ITEM	J	F	M	A	M	J	J	A	S	O	N	D
Solar Collectors												
Gate Valves and Circuit Setters												
Solar Collectors Stubs												
Collector Drain Back System												
Solar System Vaccum Breakers												
Pumps (5)												
Domestic Hot Water System												
Storage Tank	X	X		X	X	X	X	X		X	X	X
Hydronic Coils												

The symbol ☒ represents a month where the specified preventive maintenance checks are not required. When the required preventive maintenance checks are completed, the Director of Maintenance and Housekeeping should initial the open box above.

## ACCEPTANCE TEST

George C. Marshall Space Flight Center  
Marshall Space Flight Center, Alabama  
35812

Reply to Attn of FA33 (80-92)

March 18, 1980

MEMORANDUM FOR RECORD

FROM: FA33/Charles L. Greer

SUBJECT: Solar System Operational Checkout at David Wilson

Checkout of the subject solar system at the David Wilson Psychiatric Hospital at Charlottesville, Virginia, was conducted during the period of January 29 through February 1, 1980. In addition to verifying the solar system performance characteristics, the MSFC Team also used, for the first time as a site evaluation tool, an ultrasonic flowmeter recently purchased for the Site Equipment and Assessment Group. The new portable flowmeter worked extremely well. It is virtually indispensable in the checkout of a noninstrumented site such as the Wilson Hospital.

The operational checkout of the solar system was conducted using the Acceptance Test Plan furnished by Owens and Mayes (site consulting engineers) as a guide. Previous telephone discussions had resulted in modifications to the controls test procedure originally submitted by Owens and Mayes. (Both submittals are attached.)

On-site system analysis discussions with the Grantee representative and the consulting engineer were conducted to verify system operational statements made in the Acceptance Test Plan design, installation and checkout backup material. In addition to the discussions, certain flow measurements, electrical data and temperatures were recorded to provide additional supporting evidence that the system was functionally acceptable. (Recorded information is attached to this Memorandum for Record.)

General workmanship of the site solar system was good; however, some problems requiring corrective action and/or justification were noted in the solar collector plates, the solar collector internal tubing-to-header connections, the solar collector field piping insulation, the solar-to-domestic hot water heat exchanger predicted flow rate and the drain-down single failure point. The total list of open items is attached.

A number of the solar collector plates were warped to such an extent that they were touching the collector glazing. The

collectors were not leaking and none of the glazing had been damaged; however, for long term customer satisfaction, the items should be replaced or repaired by the manufacturer. Numerous internal collector-to-header connections had been overfluxed and/or not cleaned properly after soldering with the resultant potential of leaks occurring at the corrosion points. This is a warrantee item and the problem should be adjusted appropriately by the manufacturer.

The insulation discrepancies were relatively minor consisting of uninsulated vent valves, some stub pipes at the collector row ends not covered, split areas where the insulation glue joints had failed and exposed raw ends of insulation which should have been covered with appropriate paint or other sealant.

The single failure point problem will be obviated to the extent practical by a periodic drain-down timing test to be covered in the maintenance requirements in the final report. The single point failure item within the installed piping of the solar collector loop was discovered during the acceptance test. The contractor installed, by design, a buried cross-feed connection between the feeder and return piping to the collector array to insure drain down when the pumps are off. There is a valve in this line which is about one-half closed to prevent short circuiting of the collector fluid. If this valve should ever clog, the system will not drain. A method for testing the operation of the drain down was worked out during a system evaluation session. It was agreed that the periodic checkout measure would be included in the Final Report maintenance section.

As the data indicates, it was cold during the acceptance testing at Charlottesville with the complications of a 3-inch snowfall; however, the sun shown brightly and after the DOE test crew assisted the sun in removing the snow from the collectors, the system operated in the automatic mode.

The food preparation personnel at the hospital were enthusiastic about the solar hot water system. One individual stated that they had not run short of hot water since the solar system had become operational.

The contractor and Grantee's representative were cooperative in the conduction of the tests and the resulting discussions concerning the corrective actions to closeout the open items.

As of the date of this Memorandum For Record, the solar system at the David Wilson Hospital is considered acceptable to the Department of Energy since the open items list requirements have either been met, acceptable justification provided for existing conditions or effort initiated to obtain replacement and/or repair of items under warrantee. The warrantee items are presently functional but the difficulties represent potential problems which should be rectified by the manufacturer.

*Charles K. Greer*

Charles Greer  
Project Manager  
Commercial Demonstration Office  
Solar Energy Applications Projects

Concurrence:

*J. H. Brown, Jr.*  
J. H. Brown, Jr.

*3/25/80*  
Date

*R. G. Toelle*  
R. G. Toelle

*3-29-80*  
Date

4 Enclosures:

1. Acceptance Test Plan
2. Modified Controls Test Procedure
3. Data Sheet
4. Acceptance Test Summary

cc:

FA01/Mr. Swearingen w/o encl.  
FA31/Mr. Brooksbank w/o encl.  
FA33/Messrs. Myers, Brown, Toelle

FA33/Record, Reading files  
FA33/CIGreer:jsn:32054  
Rewritten: CIGreer/MLMyers:jsn:3/25/80

Note: (Inserted 13 January 1981):  
Collector problems (Leakage and plate warpage) were corrected by the manufacturer to the satisfaction of the site owner in November 1980.

# OWEN & MAYES

CONSULTING ENGINEERS

8503-A TIMBERLAKE RD

LYNCHBURG, VA. 24502

804 239-2823

JOHN M. OWEN P.E.

KARL M. MAYES P.E.

September 25, 1979

Mr. Dan Henry, FA 33  
NASA - Solar Energy Group  
Marshall Space Flight Center  
Huntsville, Alabama 35812

Dear Dan:

Please find enclosed the Acceptance Test Plan for the David C. Wilson Hospital Solar Retrofit Project. I followed the format of a set of guidelines you gave us awhile back. I hope it is in order and if you have any questions, please do not hesitate to call. Also, the project is proceeding very well. I am optimistic that it will be ready for the upcoming heating season.

Sincerely,

Owen & Mayes, Inc.

*Ernest W. Wilder*

Ernest W. Wilder

EW:pt

Enclosures

cc: Bryan Lett  
David C. Wilson Hospital



## ACCEPTANCE TEST PLAN

### DAVID C. WILSON HOSPITAL SOLAR RETROFIT

#### 1. CONTROLS TEST

This test will demonstrate the various control functions of the system in both the automatic and manual modes. The control systems to be tested are:

1. Solar collector system
2. Domestic hot water system
3. Hydronic coil for the Trane rooftop unit
4. Hydronic coil for the York rooftop unit

The solar collector system test will demonstrate that the collectors will fill and drain according to the specified degree range of the differential controller. The test will be conducted on a clear day. A permanently mounted thermometer on the solar collector circulation pump will be monitored. A similar temperature monitoring device will be located at the point where the solar collector differential controller sensor is located. When the system starts, the temperatures at the 2 points will be noted. A correct temperature differential for starting will be 6°F. A temperature monitoring device will be located in the lower part of the tank and at the approximate location of the other solar differential controller sensor. When the system stops, the tank temperature and solar collector temperature will be noted. The differential controller is adjustable across a 20°F range, which means that this controller has a 6°F on/off differential and can be adjusted to a maximum on/off of 20°F on and 14°F off or to a minimum of 6°F on and 0°F off. The adjustment of the controller will depend on several considerations which will include temperature inside the tank and cycling time of the solar collectors.

The domestic hot water system is controlled by a differential controller with the same adjustments as the solar controller. The tank sensor is at the top of solar storage and the other is at a stub located at the base of the 300 gallon preheat tank. Both locations will be mounted for temperature when pumps on both sides of the heat exchanger start and stop.

The hydronic coils supply heat to 2 heating zones inside the hospital. The coils will receive solar heated water when their respective thermostats call for first stage heat. A sequence of operation is enclosed for the hydronic coils beneath the York and Trane units. The tests for proper operation will be conducted during the heating season. The two-stage heating thermostat for the York unit will be sequenced manually to assure that the electrical heating elements in the rooftop unit energize when the room temperature cannot be maintained by the solar hydronic coil. This is accomplished by moving the thermostat to a temperature in excess of the desired room temperature.

## 2. PRESSURE REL. VALVES

The system has one pressure relief valve that is located on top of the domestic water storage tank. After filling and pressurization, the relief valve will be opened by hand. A properly operating pressure relief valve will allow water and air to pass through its venting orifice.

## 3. LEAK TEST

As part of the construction procedures, all fluid handling lines will be pressure tested prior to their filling. The lines will be plugged and pressurized at  $1\frac{1}{2}$  times their design working pressure but not less than 100 psi. After a period of 4 hours the pressure gauges will be checked for any losses in pressure.

## 4. WATER TREATMENT

The solar system storage water will have an anti-fungal and anti-bacterial chemical added to it at the time of the acceptance test plan. The additive will be a 1% solution of Drew Gard 100 or an accepted equal. The Ph level of the storage will be checked for neutrality.

## 5. BACKFLOW PREVENTION

A reduced pressure principle backflow preventer is required at the cold water line that services the solar system. The procedure for testing the device is outlined in detail in the enclosed manufacturer's brochure. The Watts brochure describes how their metering device measures pressure in the three zones of the backflow preventer.

## 6. DRAINING AND FILLING SYSTEM

The freeze testing procedure for the solar collectors is an integral part of the control test noted in Section 1. The thermistor at the solar collectors senses the return water temperature and allows the differential controller to compare this temperature with the temperature at storage. If the collector surface temperature is less than storage, the differential controller will not circulate the system. Collector system freeze-up is prevented by this control system.

The initial filling of the system will begin with the storage tank. The tank will be filled to level just below the manhole. The circulation pumps are mounted at a level above the storage tank and will have to have their discharge lines opened and filled. Foot valves at the end of the suction lines will allow the water to remain in the pipes. At this point, the circulation pumps will be primed and ready to turn on. After the pumps have circulated, vents at certain locations in the system will be observed to assure that all air has been purged from the circulation systems. The level of the solar storage tank will be monitored while all circulation systems are running. A verification of the location of the low level device will be made at this time.

The draining procedure for the various parts of the system begins with the isolation of the system components. The 300 gallon preheat tank requires

the closing of 3 gate valves and the opening of the drain cock at its base. The water will drain to the floor drain in the mechanical room.

The enclosed sketch depicts how the hydronic coils will be drained. The coil can be isolated with gate valves and the drain opened at the low point of the coil.

Each solar collector row can be isolated with a gate valve. The collectors will be in the drain down mode when it becomes necessary to replace a collector.

When the solar storage tank has to be drained, a sump pump will be lowered through the manhole and the storage water will be pumped to the nearest storm drain.

#### 7. TEMPERATURE MEASUREMENT

Temperature measurement is accomplished with permanently mounted gauges and thermistors at the remote points. These are located at the inlet and outlet of the heat exchanger and hydronic coils, and at upper and lower locations in the domestic water storage tank. The solar collectors will have remote thermistors for flow balancing.

#### 8. PUMP PRESSURE HEAD

Adequate pump pressure head is determined by the readings of the pressure gauges on each side of each pump. The pressure gauge will be monitored when the system is balanced for proper flow and temperature differentials.

#### 9. COLLECTOR FLOW

The correct flow through the solar collectors will be established through the use of the Bell & Gossett Circuit Setters and the measurements of the temperature differential across the collector rows. The circuit setter can be monitored with the manufacturer's meter. It will indicate a differential pressure which can be recalculated to determine the flow rate in the pipe.

#### 10. COLLECTOR FLOW PRESSURE DROP

Collector flow pressure drop will be tested by the use of a pressure gauge on the discharge side of the circulation pump and a pressure gauge on the main return leaving the solar collectors.

#### 11. SYSTEM OPERATION IN ALL MODES

The demonstration of the entire system in all modes of operation is related to the testing of the control functions in Section 1.

#### 12. PUMPS AND FANS

The various fans and pumps will be monitored with an amperage meter. This will verify whether the specified equipment is performing within the design conditions. The amperage loads will be checked against the manufacturer's specifications. The test procedure for the pumps is as follows:

**A. Pump Data**

1. Pump designation
2. Mfgr. & model
3. Size
4. Type drive
5. Motor H.P., volts, cycles, phase & F.L. amps

**B. Design Conditions**

1. GPM
2. Head
3. RPM
4. BHP

**C. Field Tests**

1. Discharge pressure (full flow and no flow)
2. Suction pressure (full flow and no flow)
3. Operating head
4. No load amps
5. Full flow amps
6. No flow amps
7. Calculated BHP

The demonstration procedure for the hydronic coils and fans will follow the following outline:

**A. Hydronic coil**

1. Coil designation (Trane unit or York unit)
2. Size and type
3. Face velocity, FPM
4. Entering and leaving water temperature, deg. F.
5. Entering and leaving air temperature, deg. F.
6. Pressure drop, feet of water
7. Pressure drop, air, in. WG

In order to assure proper air distribution in the ducts, the following procedural outline will be used for the Trane and York units.

**A. Fan name plate data**

1. Unit designation
2. Manufacturer and model
3. Size
4. Motor, horsepower, volts, phase, cycles, full load amps

**B. Design conditions**

1. CFM
2. Static pressure, inches of water
3. CFM outside air at minimum outside air
4. Inlet, outlet and outdoor air, dry and wet bulb temperatures, degrees F.

### C. Field test results

1. CFM
2. Suction and discharge static pressure, inches of water
3. Fan RPM
4. Fan motor operating amps

### 13. VERIFICATION OF HEAT COLLECTION PERFORMANCE

The verification of heat collection performance will begin with the monitoring of a heliopyranometer. The heliopyranometer will be located at the collector site and will be checked every 15 minutes. At every period of monitoring, the inlet and outlet temperature of the solar collectors will be noted. The test will be conducted during a clear day and while the system is under load conditions.

When the data is gathered, the heliopyranometer readings and the collector inlet/outlet temperatures will be combined to determine a collector performance curve. The curve will be compared with the collector manufacturer's curve. The solar collector performance formula  $\frac{t_i - t_a}{I}$  will be used to ascertain performance data.

### 14. VERIFICATION OF EQUIPMENT INSTALLATION

Throughout the process of construction, there have been regular visits by the engineer to verify that construction has proceeded as specified.

#### CONTROL SEQUENCE FOR YORK UNIT

1. Room thermostat calls for heat - room temperature less than 70°F - 1st stage heat activated.
2. 1st stage heat energizes existing fan relay and pump motor relay which starts fan and pump simultaneously.
3. If solar storage tank temperature is 90°F or greater, aquastat contacts to pump motor close.
4. Fan circulates return air through Aerofin hydronic coil - pump circulating water from solar storage tank.
5. If room temperature falls below 68°F, electric heater is activated. Electric heater is a 32 KW, 8 step unit. The number of steps activated is dependent upon return air temperature. (See enclosed original drawing schematic). New 2-stage heating & cooling thermostat interfaces hydronic coil operation with existing roof-top unit.

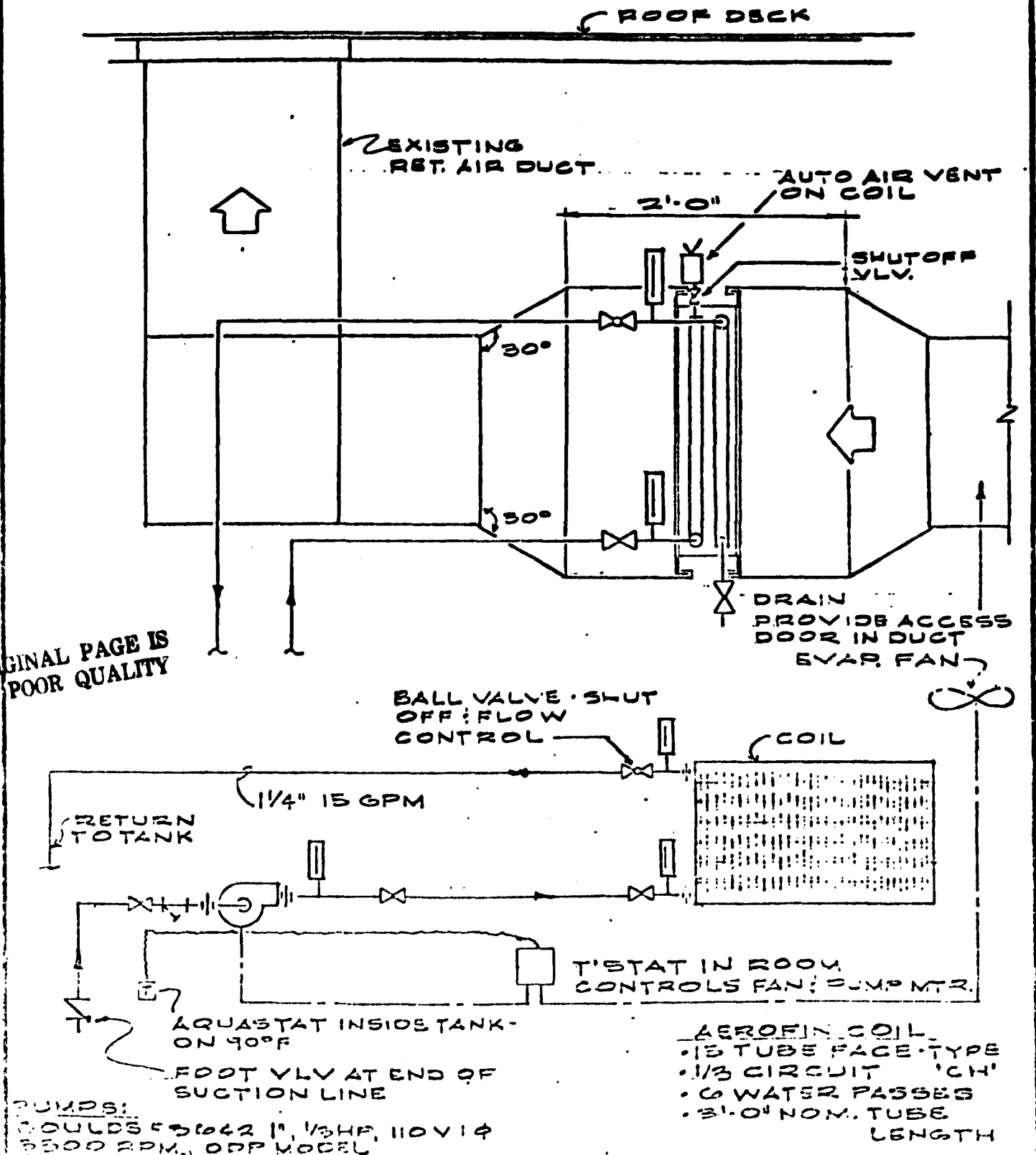
#### CONTROL SEQUENCE FOR TRANE UNIT

1. Room thermostat calls for heat - room temperature less than 70°F - single stage heat thermostat activated.
2. Relay  $R_1$  closes, pump relay contacts  $R_1$ .
3. If solar storage tank temperature is 90°F or greater, aquastat contacts to pump motor close. Pump circulates solar storage tank water.
4. When pump is running relay  $R_2$  closes relay contacts  $R_2$  to fan starter. Fan circulates return air through Aerofin hydronic coil.
5. New heating and cooling thermostat allows A.C. unit evaporator fan to function for heating and cooling. Separate existing room heat thermostat controls operation of existing hydronic wall fin tube units. These units will be active when room temperature falls to 68°F.

NOTE: Both control systems have HOA switches and running time meters with running lights.

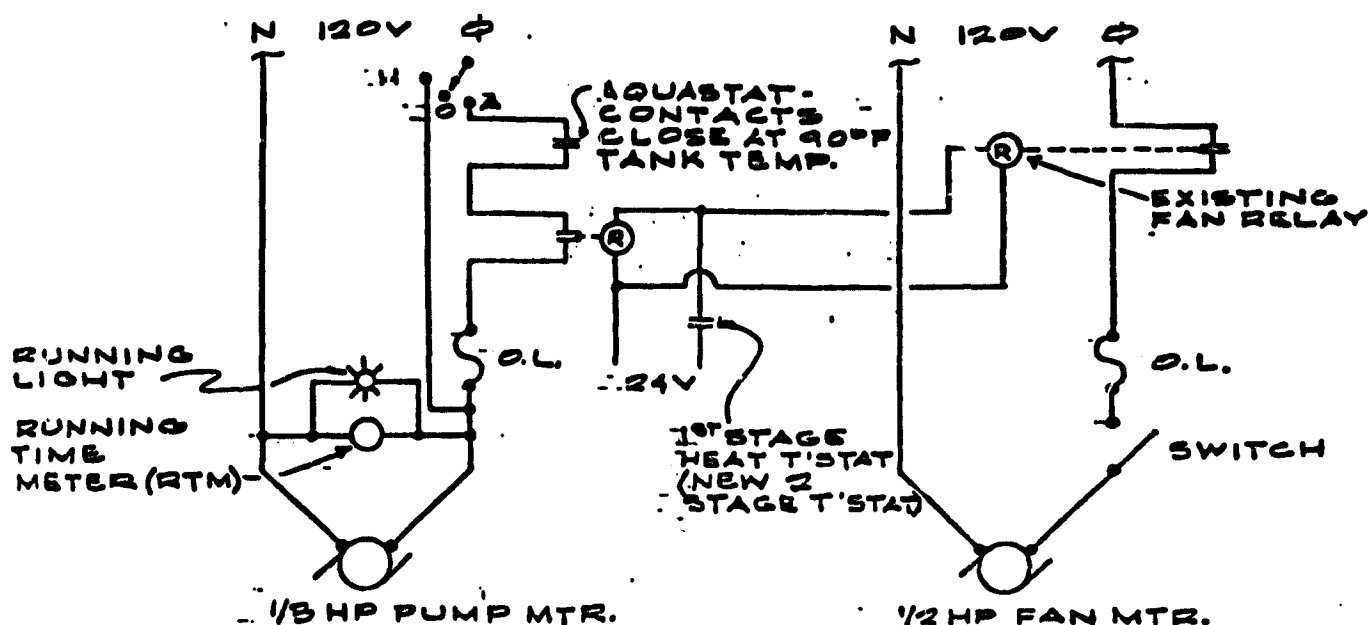
# TYPICAL HYDRONIC COIL PIPING DETAIL

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OF POOR QUALITY



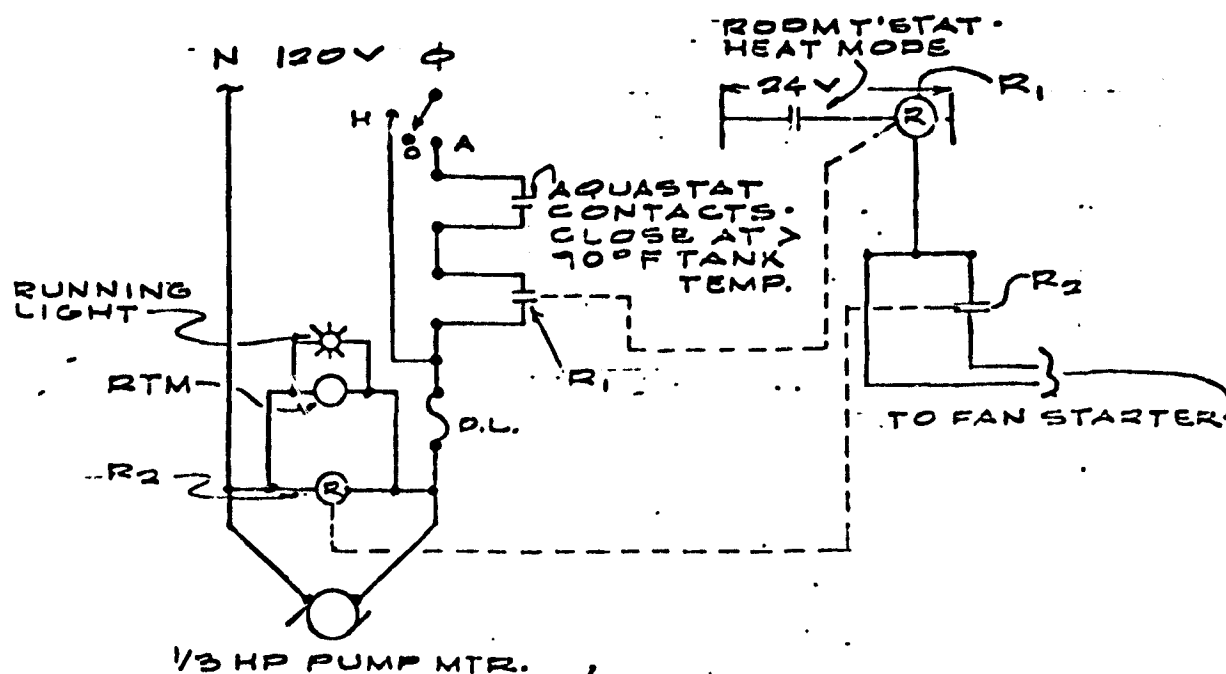
DATE:	5-20-71	DAVID G. WILSON HOSPITAL	
		SOLAR SYSTEM RETROFIT	
DRAWN BY:	EW		NUMBER: 1 OF 2
APPROVED BY:	JO	OWEN MAYES, INC.	SCALE: 1:1
		LYNCHBURG 31 VIRGINIA	

## CONTROL SCHEMATIC FOR YORK UNIT



**NOTE:** PROVIDE NEW HONEYWELL 2 STAGE HEAT/1 STAGE COOLING T'STAT. MODEL TB72 WITH R672 SUBBASE. PROVIDE LOCKING LEVER ASSEMBLY AND COVER

## CONTROL SCHEMATIC FOR TRANE UNIT



**NOTE:** REPLACE EXISTING COOLING T'STAT WITH SINGLE STAGE HEATING/COOLING T'STAT. HONEYWELL MODEL TB7F. PROVIDE T'STAT GUARD

DATE:	6-20-74	DAVID C. WILSON HOSPITAL	NUMBER:	2 OF 2
DRAWN BY:	EW	SOLAR SYSTEM RETROFIT.	SCALE:	NA
APPROVED BY:	JO	OWEN: MAYES, INC.		
		LYNCHBURG 32 VIRGINIA		

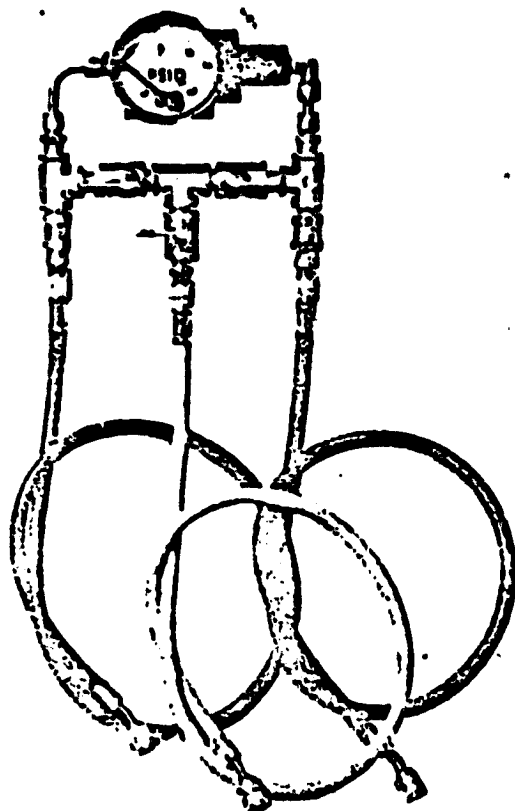


# WATTS

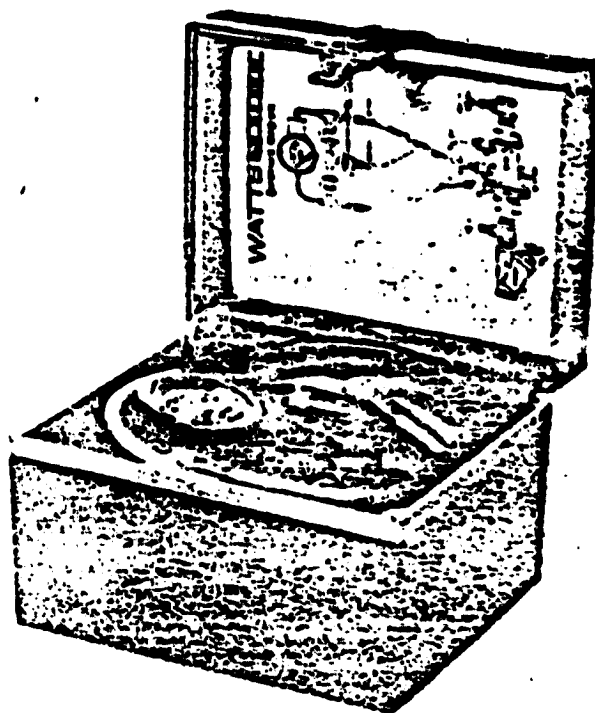
The name  
that protects  
your name

103 Years Of Leadership 1874 - 1977

## No. TK-9 Backflow Preventer Test Kit Operating & Field Test Procedure



The Watts Model No. TK-9 Backflow Preventer Test Kit is a compact portable testing device especially made for testing all Reduced Pressure Principle Backflow Prevention Devices. The TK-9 is easily connected to any RPZ device enabling accurate testing of "zone" differential pressure, relief valve opening differential, fouled check valves or similar problems that visual inspections cannot locate. The unit is encased in a rugged carrying case for easy handling and accessibility.



### SPECIFICATIONS

- Maximum working pressure - 500 psi.
- Maximum working temperature - 210°F.
- Gauge - 0-15 psid with  $\pm 2\%$  accuracy, full scale.
- Hoses - (3) 3' with  $\frac{1}{2}$ " female threaded couplers.
- Adapters - (3)  $\frac{1}{4}$ " threaded adapters  
(3)  $\frac{1}{2}$ " bushings  
(3)  $\frac{3}{4}$ " bushings
- 1 - 16" securing strap.
- 1 - Moisture resistant instruction guide.
- Case - shock resistant molded plastic with special diced foam insert that enables multiple compartment combinations for tools, accessories or similar items.

# WATTS

WATTS REGULATOR COMPANY  
TORONTO, CANADA

LAWRENCE, MASS., U.S.A.  
GLOUCESTERSHIRE, ENGLAND

Manufacturers of the largest and most complete line of plumbing and heating safety valves and controls

**LIMITED WARRANTY:** Watts Regulator Company warrants each product against defects in material and workmanship for a period of one year from the date of original shipment. In the event of such defects within the warranty period, the Company will, at its option, replace or recondition the product without charge. This shall constitute the exclusive remedy for breach of warranty, and the Company shall not be responsible for any incidental or consequential damages, including, without limitation, damages or other costs resulting from labor charges, delays, vandalism, negligence, flooding caused by foreign material, damage from adverse waste conditions, chemicals, or any other circumstances over which the Company has no control. This warranty shall be invalidated by any abuse, misuse, misapplication or improper installation of the product. THE COMPANY MAKES NO OTHER WARRANTIES EXPRESS OR IMPLIED EXCEPT AS PROVIDED IN THIS LIMITED WARRANTY.

# TEST DATA

amb. temp.	temp. in solar loop	temp. out solar loop	insolation	flow gal/min	time	current voltage 30
			50		9:20	
30°	68.5	66	60	46.6	2:12	
30°	69.0	62	60	46.9	2:17	47
30°	69.1	63	63	47.1	2:21	211
30°	69.3	63	50	47.1	2:25	

Wednesday, January 30, 1980  
Solar taken about 10:00 a.m.

Insolation between 9 a.m. and 5 p.m. was 425 BTU/sq. ft. total

NOTE: System did operate automatically from 1:45 to 1:57, outside temp. 32°.

System required about 15 minutes to drain down.

P-1 (Heat exchanger to preheat tank) 8.24 GPM (4.9 at 120v-rates 4.9 amps

P-2 (Solar to heat exchanger) 8.5 GPM (4.5 amps at 120v-rates 4.9 amps

Heating coil pumps P4-P5 (simultaneously) common inlet 12.9-13.12 GPM

P-4 - Flow: 13.87-14.09 GPM 7.4 amps run (rating 6.8-8.4)  
27 amp start

P-5 - Flow: 13.84-14.15 GPM 6.7 amps run (rating 6.8-8.4)  
27 amp start

After snow was removed from collectors on Thursday, January 31, 1980, the system came on automatically at 10:55 a.m.

Friday, February 1, 1980  
Automatic operation

time	solar panel supply temp.	domestic in temp.	domestic out temp.	solar in temp.	solar out temp.
9:30	78°	68°	65°	80°	70°
10:30	82°	62°	70°	85°	73°
11:10	90°	72°	79°	91°	81°
2:30	110°	79°	90°	112°	95°

**Operational Checkout of Solar System Installed at David C. Wilson Neuro-psychiatric Hospital Charlottesville, Virginia was completed on January 31, 1980.**

**Test Participants:**

**Bryan Lett - Hospital Administration**

**John Owens            Owens and Mayes  
Ernest Wilder       Consulting Engineers**

**Will Davies           Solar Engineer**

**Department of Energy (MSFC):**

**Ron Toelle  
W. T. Powers  
Joe Brown  
Charles Greer**

# DEKO-LABS

Friberg-DeKold Corporation

PRECISION ELECTRONIC PRODUCTS • CUSTOM ELECTRONIC DESIGN • ELECTRONICS MANUFACTURING • CONSULTING

BOX 12841, UNIVERSITY STATION  
Route 4, Box 256  
GAINESVILLE, FLORIDA 32601  
(904) 372-6009

DONALD F. DeKOLD, President  
BS, BSEE, ME  
Member: IEEE

## INSTRUCTIONS FOR USE OF DIFFERENTIAL ADJUSTMENT CONTROL

The Differential Adjustment Control is a small component centrally located on the circuit board of the TC-3 Comparator. A slotted head plastic screw on this control permits easy screwdriver adjustment of the Turn-on and Turn-off Differentials in the unit. (See attached instructions for meaning of "Turn-on" and "Turn-off" differentials.) Access to the control is gained by removal of the cover of the TC-3.

When the control is varied from stop to stop in a clockwise direction, the Turn-on Differential varies from 0 Fahrenheit degrees to 20 Fahrenheit degrees (plus). The Turn-off Differential always stays a relatively constant 5 Fahrenheit degrees lower than the Turn-on Differential. Thus, as the Turn-on Differential is varied from 0° to 20°, the Turn-off Differential varies from -5° to 15°.

Upon shipment the Differential Adjustment Control has been been factory adjusted to provide the standard differentials of 10° turn-on and 5° turn-off. This setting may be repeated in the field by aligning the long axis of the screwdriver slot towards the small white dot on the control. The screw is nearest its most counter-clockwise stop when properly lined up on the calibration mark.

The differentials will not remain constant as operating temperatures monitored by the comparator sensors vary. However the amount of variation in differentials is small. The differentials cited above are for the case when the reference sensor (storage sensor) is at a nominal temperature of 135°F. As the reference sensor temperature drops to 100°F, the magnitude of the differentials (both turn-on and turn-off) decrease by about 10% for the same setting of the Differential Adjustment Control. As the reference sensor temperature rises to 170°F the magnitude of the differentials increases by about 10%.

# INSTRUCTIONS MODEL TC-5 TEMPERATURE COMPARATOR

## DESCRIPTION

KO-LABS Model TC-5 Temperature Comparator Controller is a differential thermostat used for general solar heating applications. When one of the two sensors provided with unit rises nominally 10° F above the other sensor, a power control relay is energized. When the first sensor drops to within 5° F of the second sensor, the control relay contacts open. As long as the "turn-on differential" of 10° F is exceeded, the control relay is energized holding its power contacts closed; however, when the temperature difference is 5° F or less, the relay contacts open. (The 5° F value is designated as the "turn-off differential".) The first sensor is called the COLLECTOR sensor since when properly installed monitors temperature of water in a solar collector. The second sensor is called the STORAGE sensor since it monitors temperature of a storage medium such as a rock bin or hot water tank.

## IFICATIONS (standard model with no options)

ATING VOLTAGE - 105 to 125 vac, 60 Hertz.

RELAY CONTACT RATING - 1/3rd H.P. inductive load.

ON DIFFERENTIAL - 10° F (±1° F) for Storage Sensor at 135° F.

OFF DIFFERENTIAL - 5° F (±1° F) for Storage Sensor at 135° F.

OR MATCHING ACCURACY - 1° F or less at 135° F.

MAXIMUM SENSOR TEMPERATURE - 300° F.

## UP & CHECK-OUT

the controller in any position or any location which is convenient, but which is clear from the elements. Aesthetics and economy of running power leads should dictate location, since there is no restriction on length of leads to the sensors. Connections to circuit terminal strip inside the controller enclosure should be made according to the illustration below. ALL CONNECTIONS SHOULD BE MADE IN ACCORDANCE WITH LOCAL ELECTRICAL CODES.

terminals of the barrier strip inside the controller are color-coded and additionally are marked on the bottom side of the printed circuit board.

The COLLECTOR SENSOR is connected to the RED (1) and BLACK (2) terminals.

The STORAGE SENSOR is connected to the GREEN (3) and BLACK (2) terminals.

Route 117 vac into the BLUE (4) and WHITE (5) terminals.

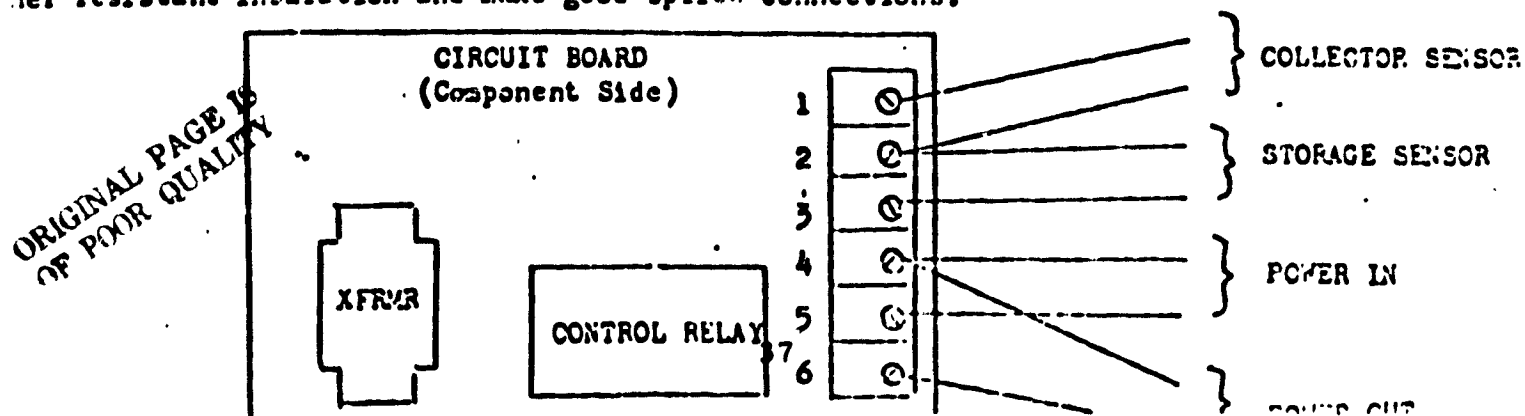
The load is connected to the BLUE (4) and YELLOW (6) terminals.

The metal case of the controller should be grounded for safety.

the RED-BLACK terminals shorted, the control relay should be energized and contacts closed.

the GREEN-BLACK terminals shorted, the control relay should be de-energized and contacts open.

hook-up wire to the sensors may be a light gauge wire such as doorbell wire, preferably a twisted pair. Avoid running sensor hook-up wire parallel to power lines. Use hook-up wire which has better resistant insulation and make good splice connections.



# DAVID C. WILSON HOSPITAL SOLAR RETROFIT

## DIFFERENTIAL CONTROLLER SPECIFICATIONS

### Manufacturing:

Deko-Labs  
Mr. Don Dekold  
Route 4 Box 256  
Gainesville, Florida 32601  
Phone: (904) 372-6009

### Ordering Specifications:

- 2 TC-3 Differential Controllers
- No Enclosure for each
- 3 Precision Sensor Pairs
- On-Off Light for each
- 7° F Internal temperature differential adjustable over a 20°F degree range - custom differentials for each

Use 18 AWG sensor wire, twisted pairs in a shielded cable for all sensor connections. Cable used should be Belden or an approved equal. The 3 pair of precision sensors are located as follows:

1. Domestic hot water 300 gal. tank. One sensor at union located at base of tank. This is the suction line to the pump for the heat exchanger. Mount the sensor in a heat transfer mastic such as "Chemax" or "Thermon" or an approved equal. Mount sensor as close to tank exterior as possible. When insulating pipe, insulate directly over sensor. (See enclosed sketch).
2. The other 2 precision pairs will be mounted on the solar collectors. One pair will be operational. The other sensor will be mounted but the leads will be left bare in the control box for future connection in the event the primary sensor fails. (See enclosed sketch).

All pump motor starters will have HOA switches. The pumps to the hydronic coils will have running time meters and on/off lights in the control box.

**APPENDIX A**  
**MANUFACTURE'S LITERATURE**

## internal manifold Solector®

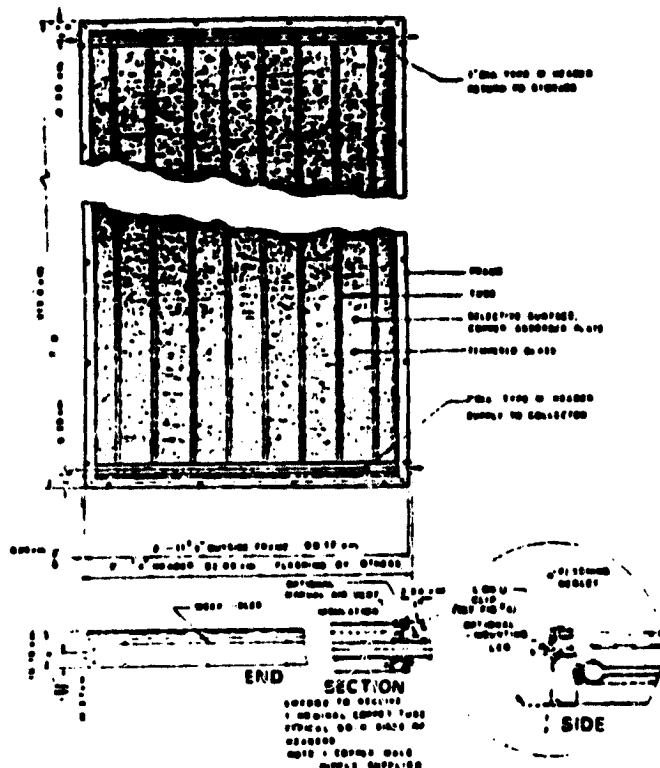


FIGURE 1

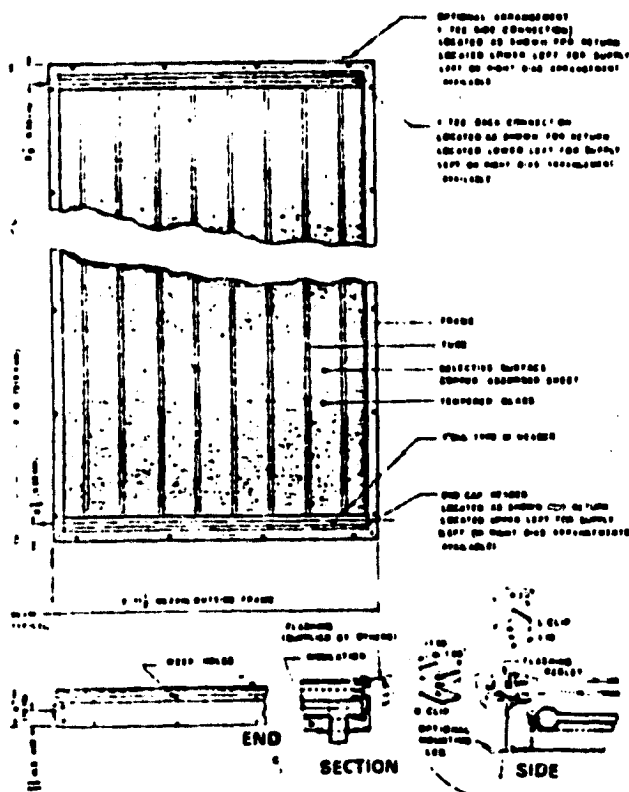


FIGURE 2

The 3' x 7' liquid cooled Solector solar energy collector, with internal manifolding and side, sideback or side/end connections allows for a multi-panel array to be coupled in parallel or parallel series before returning to the main supply or return branch. This results in fewer field connections and fewer piping accessories while retaining a high installed net to gross ratio, approximately 88 percent. The internal manifold liquid cooled Solector is available with connection locations that allow side-by-side mounting for parallel flow or end-to-end mounting for series flow. This Solector configuration responds to the specific design requirements of solar collector arrays for commercial, industrial, and institutional building types by maximizing the amount of collectors able to be placed onto the structure while minimizing the installed cost.

### FEATURES AND CONSTRUCTION:

**Cover:** Single glazing: lo-iron (A.S.G.), 1/8 inch (.32 cm) tempered, edges swiped. Double glazing: lo-iron (A.S.G.), 2-1/8 inch (.32 cm) tempered, with weep holes. Total transmissivity: Single glazing, 89.1%; Double glazing, 79.3%. (A.S.G. 1/8" or 1/4" no iron also available.)

**Absorber Container:** Sides, aluminum extrusion; rear aluminum sheet .032 inches (.058 cm) thickness, pop rivet in place.

**Air Space Between Cover and Absorber:** Approximately 3/4 to 1 inch depending upon glazing type.

**Gasketing Material:** EPDM "U" gasket for glazing, closed cell elastomer, compressible high temperature silicone seal for absorber sheet.

**Weatherproofing:** This module can be placed out in the weather without need for further weatherproofing.

**Finish on Aluminum Sides of Container:** Standard mill finish, anodized clear or baked black enamel (available at extra cost).

**Dimensions of Surface-Mounted Module:** Outside dimensions overall: 35 1/2 inches (90.2 cm) wide x 84 inches (213.4 cm) long x 4 inches (10.2 cm) thick (add 1 1/4 inch each end for optional continuous mounting bracket). Effective absorber area = 18.50 ft² (1.72m²). Ratio of usable absorber area to total installed surface covered = 0.88. Glass area (aperture) = 18.88 ft² (1.75m²).

**Absorber:** Copper sheet: .010 inches thick (.025 cm) (7 ounces). Selective black: minimum absorptivity, .85/.92; maximum emissivity, .15/.35. Manufactured by Enthone, Incorporated; guaranteed durable to 400°F (305°C). (Black chrome: absorptivity, .94 emissivity .12 also available.) Copper tubes: 1/2" O.D., 4 inches (10.2 cm) on center, L-type copper. Tube pattern: grid. Bond between tube and sheet: high temperature solder, 270° wrap. Manifolds: 1 inch type M copper. Tube connections to manifold: brazing alloy. Connection to external piping: 1 inch type M copper tube. Manifold/tubes pressure tested before leaving factory to 15 atm; recommended 125 psig (8.5 atm) working pressure.

**Insulation Behind Absorber:** .5 in. (1.25 cm) thick glass fiber (compressed) over 1.0 inch (2.5 cm) thick foil-faced isocyanurate, R = 10.0, (glass fiber, 1.2 lbs/ft³ density).

**Method of Anchoring:** Keyway integral to collector frame continuous along perimeter of frame designed to accept "L" or "U" clips with predrilled 1/2" diameter hole for bolt mounting to roof or frame. Optional 1 1/4 inch (3.2 cm) mounting leg integral with top and bottom of frame; four 1/2" (.95 cm) diameter holes predrilled. Capability of through bolt anywhere along its length.

**Weight Per Module:** 123 pounds (55.8 kg), filled; 120 pounds (54.4 kg), empty (standard 3' x 7' unit). Add 27 pounds (12.2 kg) for double glazed unit. The liquid in the solector is equal to 0.48 gallons (1.82 liters).

**Recommended Flow Rate Through Collector:** 28 lbs/h/ft² (1 gpm) (.063 l/sec) per collector.

**Collector Coolant:** Coolant should be Sunsol 60, made by Sunworks or equivalent. In areas where regular tap water is used as a coolant, it is important that the pH be controlled between 6.5 and 8, and the Ca/Mg count should be below 50 ppm.

**Warranty:** Five year material workmanship warranty on all parts effective from date of installation. See your local Sunworks representative for further details.



***SUNWORKS***

**INSTALLATION  
and  
MAINTENANCE  
INSTRUCTIONS**

## INSTALLATION INSTRUCTIONS

### MOUNTING

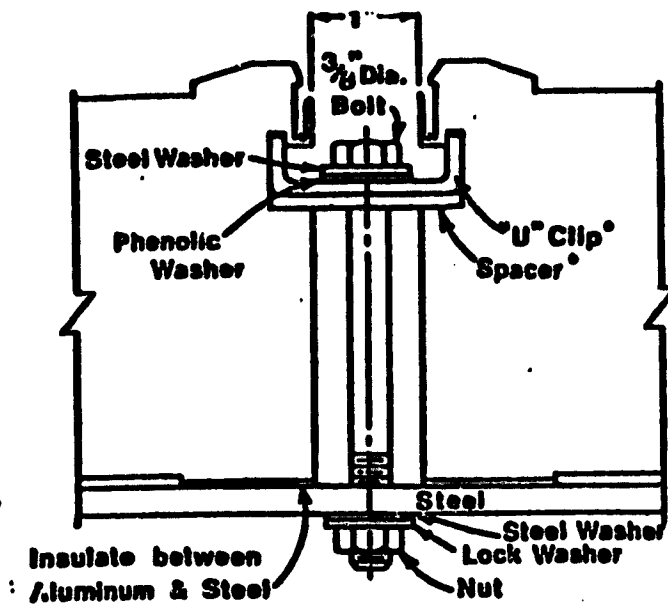
#### Internal Manifold Selector<sup>R</sup> (Models B, C, D, F, G)

Mount the first collector of the group on the support structure provided. The anchor bolts should be isolated from the aluminum mounting leg on the Selector<sup>R</sup> unless they are stainless steel. A phenolic washer or a washer wrapped with teflon tape will keep the bolt head off the mounting leg. Wrapping the shaft of the bolt head close to the head with 4 or 5 turns of teflon tape will also provide protection. Alternatively, a short sleeve of neoprene tubing may be slid over the lag bolt to isolate it from the mounting flange. It is important that the first collector be accurately placed. Note the weep holes located in the groove of the extrusion are at the bottom and the decal arrow on the glass cover points upward. If optional "U" and "L" clips are used see Figs. 1, 2 and 3. If standard mounting legs are used see Fig. 4.

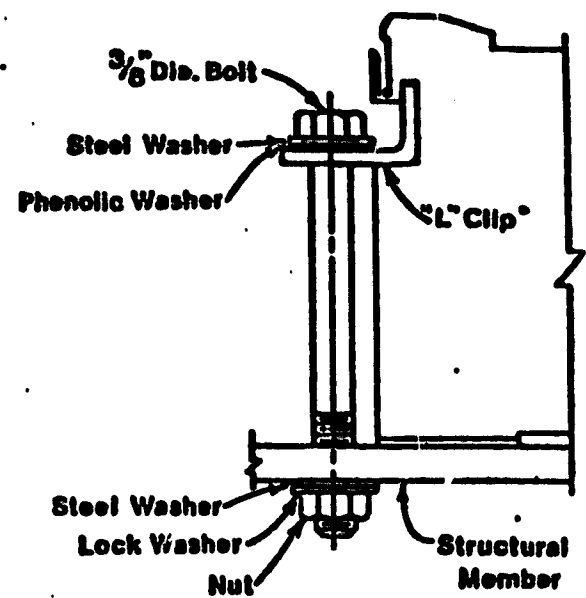
A chalk line or temporary attachment of a "two by" horizontally will help align succeeding collectors. Adjust absorber plate assembly so that swedge connections protrude equally from sides of Selector<sup>R</sup>. Solder supply line to the first collector. Use 95/5 tin antimony solder at all collector connections; 50/50 solder can be used elsewhere. Insert connector nipples supplied by Sunworks into swedges of the first collector. Using a (1) one inch block as a spacing gage mount the balance of the array inserting the connector nipples in the same manner as the first collector. DO NOT SOLDER the connecting nipples until the entire Side-to-Side group is mounted. Use 95/5 tin antimony solder for connections between collectors.

#### Drain Down Selectors<sup>R</sup> (Models A, E)

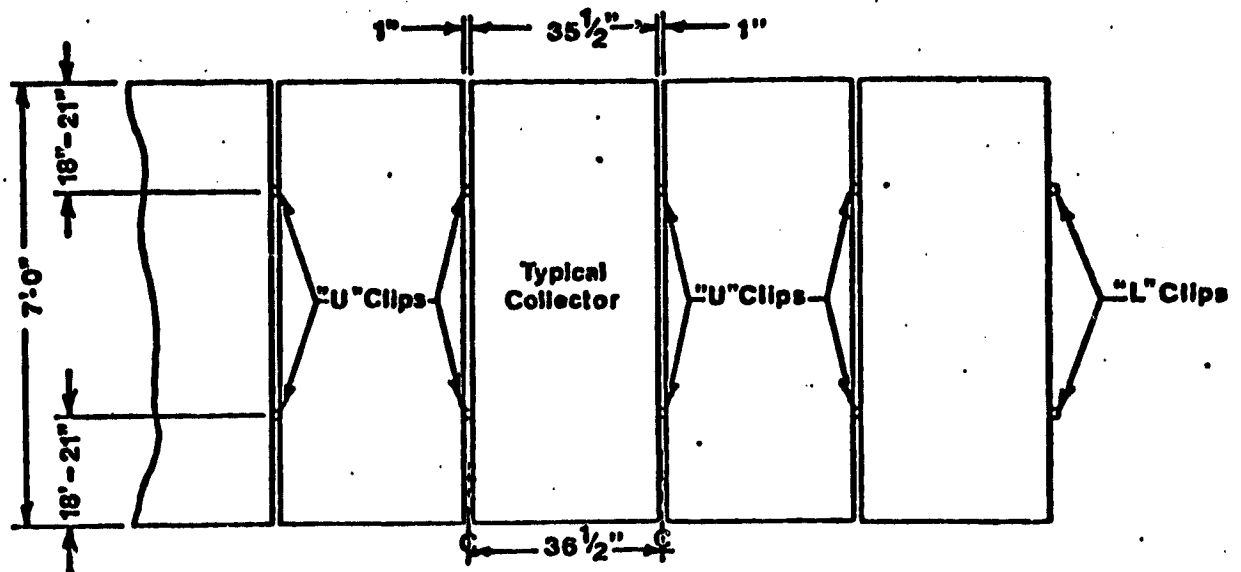
Mount the first collector on the support structure provided. The spacing between collectors should be at least (1/4") one quarter inch to allow for expansion of the aluminum frame. Mount entire array before soldering connections.



**Fig. 1**



**Fig. 2**

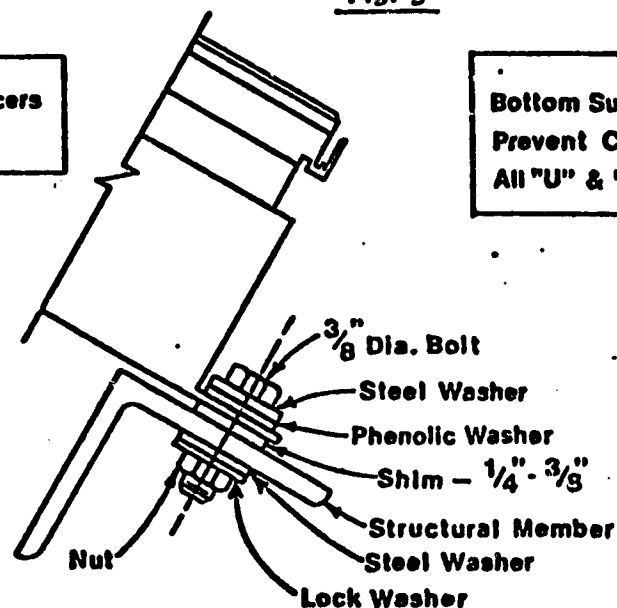


**Fig. 3**

• "U" Clips, "L" Clips, & Spacers  
Provided by SUNWORKS.

Bottom Support Required to  
Prevent Collector Slippage in  
All "U" & "L" Clip Mountings.

5 Wraps of Teflon Tape or  
Equal around Bolt Body to  
Isolate Different Metals.



**Fig. 4**

## **PLUMBING/PIPING**

The piping in the entire system should be copper; type in accordance with local plumbing codes. Use 95/5 tin antimony solder at the Solector<sup>®</sup> connections. All other connections may be 50/50 solder. Supply and return piping should slope to facilitate air venting and gravity draining. Flush the system thoroughly with water.

## **HYDRAULIC TESTING**

After thoroughly flushing the system, fill the loop with water. The closed loop should be raised to 60 psi with a high pressure transfer pump. In drain down systems, use pressure available through supply main. If city water pressure exceeds 125 psi, a pressure reducing valve should be installed. Use either reducing valves that allow reverse flow of water or an expansion tank capable of withstanding city water pressure. The system should hold pressure for at least (1) one hour. Inspect for leaks if pressure drops during this period. If the outdoor temperature is below freezing when the pressure test is conducted, a non-freezing fluid (permanent solution) should be used in close loop systems. The following procedure should be used to pressure test open loops (drain down) systems in freezing conditions: 1) Isolate outdoor piping by closing appropriate valves. 2) Fill outdoor piping with a non-freezing solution and pressurize to 60 psi. 3) Hold for one hour. 4) Drain outdoor piping and flush thoroughly with water. After successful completion of the pressure test, a transfer pump can be used to force the permanent solution into the closed loop system. The system should be pressurized to twenty-to-thirty (20-30) psi. Do not overpressurize. Check functions of all valves. Connect drain lines as required by local codes.

## COLLECTOR PIPING CONFIGURATIONS

A standard collector array uses an external pipe which must be insulated and is usually piped for Reverse/Return flow (Fig. 2-6). Sunworks internal header collectors (Fig. 2-7) are joined together with nipples provided by Sunworks which automatically pipes the header in reverse/return parallel flow. Normally six collectors are the maximum that would be connected together in a bank in order to maintain system balance. When more than six collectors are connected in one bank performance begins to fall off and pressure drop begins to increase. Balancing of flow through each collector is also effected with connection of more than six. More than six collectors should not be connected in parallel through internal headers without consulting Sunworks' engineering Department.

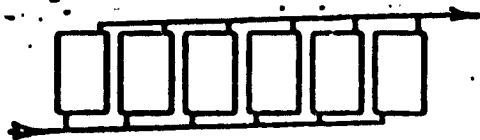


Fig. 2-6 Standard Collector Array



Fig. 2-7 Sunworks Internal Header Array

For larger arrays it is sometimes expedient to connect banks of collectors in series. For a standard collector array this would still require insulated pipe headers and may require extensive spacing between banks (Fig. 2-8). The use of Sunworks internal header collectors with optional outlet connections allow a neater arrangement without extensive external headering (Fig. 2-9).

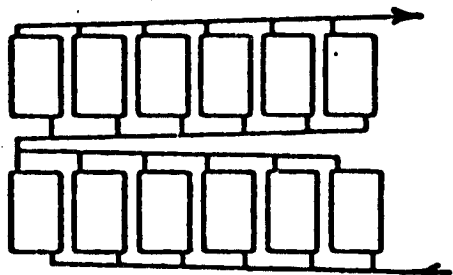


Fig. 2-8 Standard Collector Array  
Two Banks In Series

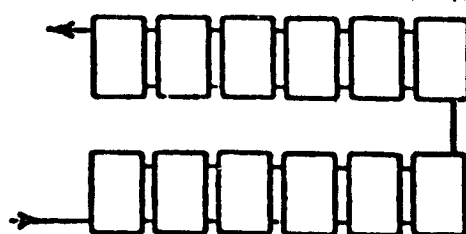


Fig. 2-9 Sunworks Internal Header Array  
Two Banks In Series

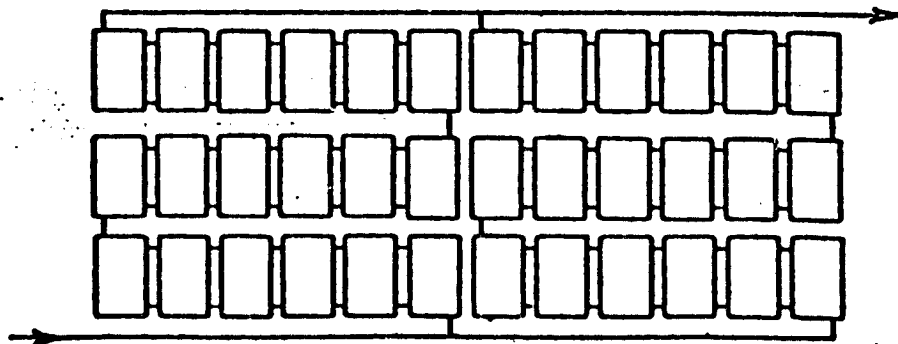


Fig. 2-10 Sunworks Internal Header Array  
Two Groups Of Three Banks In Series - Piped In Parallel Flow Reverse/Return

Fig. 2-10 illustrates a method of grouping large arrays into close clusters on a pitched roof. Use of Sunworks internal header collectors with optional outlet locations allow the 36 collectors shown to be piped into two groups of three banks each in series. Large arrays piped in this manner have the disadvantage of slight loss in collector efficiency due to higher collector temperatures caused by series operation; but, have the advantage of using a lower system flow rate resulting in smaller pumps and lowered pumping energy use.

Since the number of collectors in parallel are the only ones taken into account when figuring Flow Rate, the array shown in Fig. 2-10 would have a flow of 12 times the recommended Flow Rate per collector  $1/2$  to 1 GPM collector; in other words, 6 to 12 GPM for the entire array.

## REPLACEMENT, REPAIR & OPERATING RESTRICTIONS

### IMPORTANT NOTE:

Solar collectors become very hot when exposed to sunlight while not operating! If at all possible it is advisable to do any work required when collectors are relatively cool. Whenever this is not possible, precautions should be taken (such as wearing gloves) to avoid skin contact with any part of the collector.

## REPLACING A SOLECTOR MODULE

- 1) Collectors at the ends of an array can be easily removed.
- 2) Removal from the other locations can be accomplished as follows:
  - a) Assume Selector "B" is to be removed. See Fig. 1.

1" Dia. Nipple Typ 4 pls.

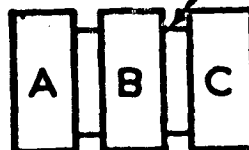


Figure 1

- b) Accurately measure the distance between the swedges. ("X" equals the length of the exposed connecting nipple). See Fig. 2.

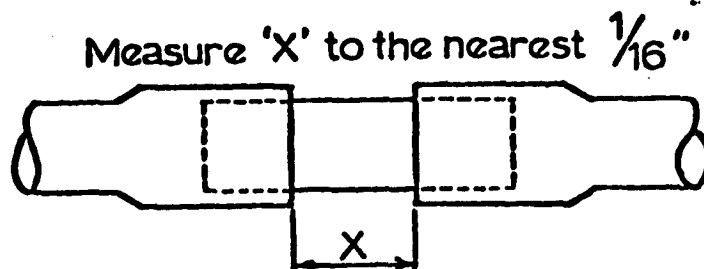


Figure 2

- c) Clean 4 - 2" pieces of 1" type M Copper Tubing with emery cloth. Place a mark with tube cutter 1/4" in from the end of the tube. See Fig. 3.

1" Dia. Type 'M' Tubing

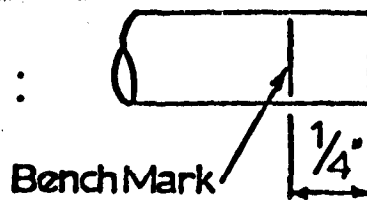


Figure 3



- d) Cut the connecting male couplings in the middle with a thin hack saw blade. Avoid Damage to the Swedges.
- e) Remove collector "B" from the array.
- f) Remove stubs from collectors "A", "B" and "C" and any solder remaining in the swedges. Emery cloth or wire brush is helpful.
- g) Apply flux to all swedges.
- h) Cut the 4 pieces of Type M tubing  $1/2"$  longer than the measurement "X". The  $1/4"$  bench mark is included in the overall dimension ( $1/2"$  plus "X").
- i) Insert the four (4) male coupling nipples into the swedges of collector "B" until they stop. See Fig. 4.

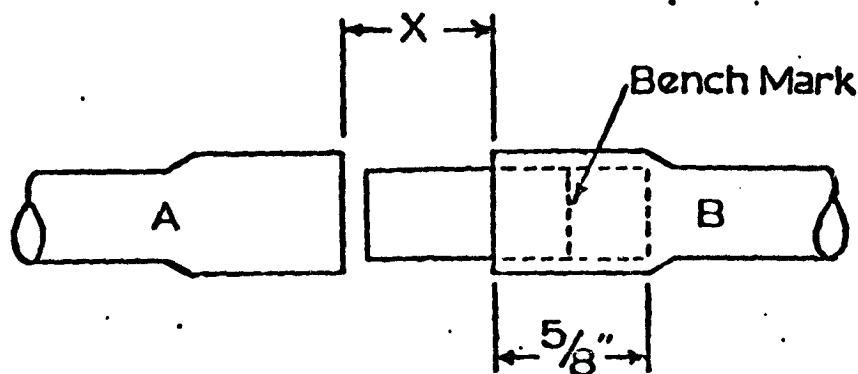


Figure 4

Example: Assume "X" =  $1/4"$   
 Add  $1/2"$   
 Nipple lg. =  $3/4"$

Nipple shown in stopped position.

- j) Carefully place collector "B" into position. Note there is only  $1/8"$  gap between end of header swedge and edge of nipple. See Fig. 4.
- k) Align swedge of adjacent collector with coupling nipple and slide nipple into swedge until bench mark is in alignment with edge of swedge. See Fig. 5.

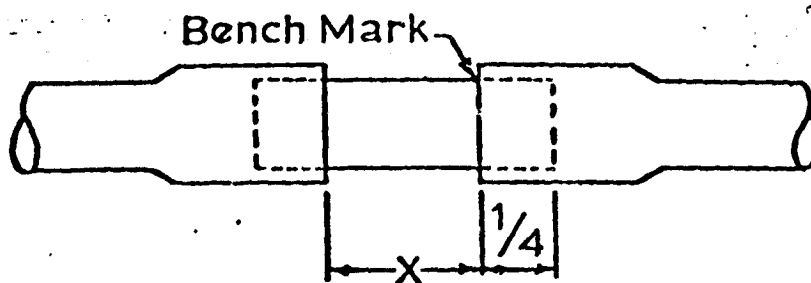


Figure 5

- l) Use needle nose pliers or similar tool to move connector nipple into position.
- m) Repeat for all other connections.
- n) Solder connections with 95/5 tin antimony.
- o) Check for leaks by pressurizing system.

**NOTE:**

A generous quantity of flux paste on the connecting nipple and in the swedges will permit the nipple to slide into position easily. A channel-lock plier may be used instead of needle point pliers.

ORIGINAL PAGE 2  
OF FOUR QUALITY

### REPAIR OF SOLECTOR MODULES

The only repair that should normally be attempted in the field is replacement of broken glazing(s). Replacement must be with pre-cut tempered glass supplied by Surworks. Do Not attempt to use standard window glass or any other substitute without express approval by Surworks. Replacement is accomplished by simple removal of 16 screws that hold down the glazing cap.

After removal of the four pieces of glazing cap, all pieces of broken glass can be removed. Particular care should be taken to avoid damage to the absorber surface. Since an exposed absorber surface becomes hot enough in sunlight to cause serious burns, exercise extreme care.

Remove all pieces of broken glass from the glazing gasket and re-install the gasket on the new glass. After this is done, the new glass can be laid in place. Ensure that the glass is evenly in position and the gasket is not twisted or pinched. Remove all silicone sealant from the mitered edges of the 4 glazing cap sections and apply new sealant to each edge. The glazing caps can then be screwed back into place.

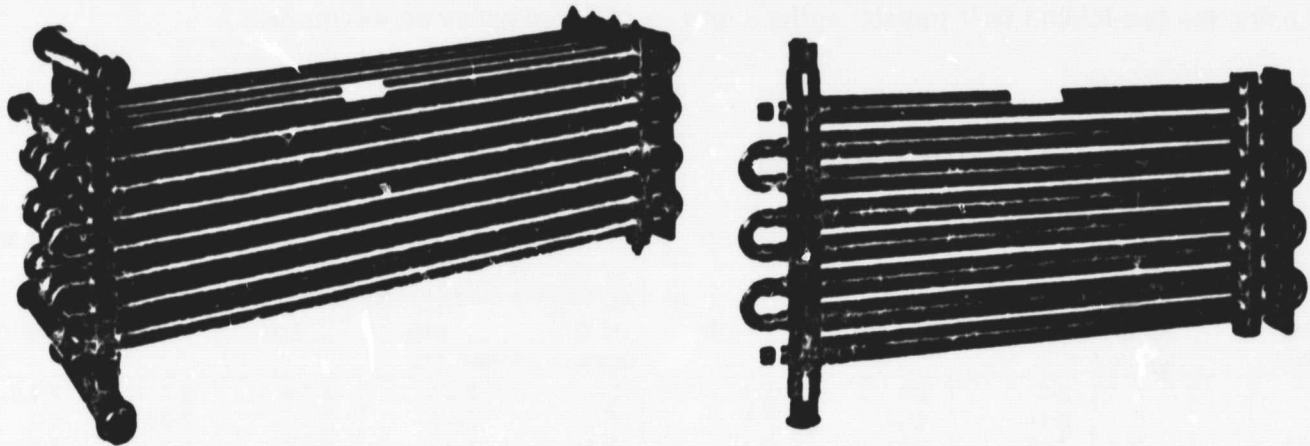
## **OPERATING RESTRICTIONS**

Sunworks Sollectors<sup>R</sup> are made from the best materials available for maximum longevity under most operating conditions. Since there are no moving parts, the only restrictions and/or precautions necessary are those which would normally be observed for the respective materials. Such restrictions would include:

1. Ph of fluid should be maintained in the range of 6.5 to 8 and hardness at a maximum of 500 ppm TDS.
2. In areas where the collectors may be exposed to aggressive atmospheric conditions, thought should be given to special protective coatings for the aluminum enclosure.
3. Sunworks Sollectors<sup>R</sup> are factory tested to 250 psig. As such maximum working pressure is 125 psig and should not be exceeded.

HEAT TRANSFER DIVISION

# VENTED DOUBLE WALL SOLAR HEAT EXCHANGERS



## HEAT EXCHANGERS FOR POTABLE WATER HEATING

- VENTED DOUBLE WALL PROTECTION
- MECHANICALLY CLEANABLE HEAT TRANSFER SURFACE
- POSITIVE THERMAL CAPACITANCE CONTROL
- EXCLUSIVE DOUCETTE FAIL-SAFE DESIGN
- MEETS H.U.D. MINIMUM STANDARDS
- U.L. RECOGNIZED FOR POTABLE WATER
- VIRTUALLY UNLIMITED DESIGN FLEXIBILITY
- MODULAR CONSTRUCTION FOR INVENTORY CONTROL
- DESIGNED SPECIFICALLY FOR SOLAR FLUIDS
- ALL COPPER TUBE CONSTRUCTION

**doucette industries, inc.**

"INNOVATORS OF THE VENTED DOUBLE WALL"

P. O. Box 1641, York, PA 17405 • 717-845-8746

# SOLAR HEAT EXCHANGERS

The Doucette Industries' clearable solar heat exchanger with the vented double wall represents the ultimate combination of contamination protection and heat transfer capability. The vented double wall (patent applied for) is recognized by U.L. for potable water and gives the ultimate protection for both the water side and the solar system. Any leak—anywhere in the heat exchanger—will leak to the outside and will not cross-contaminate. Simply by removing several bolts, the low-fouling heat transfer surface may

be cleaned with a wire brush, eliminating the need for acids and chemicals. The solar fluid and water circuits are designed to balance thermal capacitance rates to insure maximum surface utilization and limit pressure drops. All copper tube construction insures corrosion resistance and long operating life. On larger systems, several devices are manifolded in parallel to control fluid velocity, giving unlimited design flexibility. This modular feature permits a wide range of applications without extended inventories.

## Performance Specifications

Collector Rise—"F"/°F		0.05                  0.11                  0.25                  0.43                  0.67                  1.0                  1.5                  2.33									
Water Flow Rate (gpm)	Solar Flow Rate (gpm)	HEAT EXCHANGER EFFECTIVENESS									
		0.95                  0.90                  0.80                  0.70                  0.60                  0.50                  0.40                  0.30									
MODEL NUMBER CS-											
3.5	50% Glycol	1	Z-8	Z-7	Z-6	Z-4	Z-3.5	Z-2.5	Z-2	Z-1.5	
		2	Z-11	Z-10	Z-8	Z-6	Z-4.5	Z-3.5	Z-2.5	Z-2	
		3	Z-18	Z-14	Z-11	Z-8	Z-6	Z-4.5	Z-3.5	Z-2.5	
		4	Z-23	Z-18	Z-13	Z-10	Z-7	Z-5	Z-3.5	Z-2.5	
		5	Z-30	Z-25	Z-18	Z-12	Z-9	Z-6	Z-4	Z-3	
13		6	Z-36M18	Z-28M14	Z-22M11	Z-16M8	Z-12M6	Z-10M5	Z-8M4	Z-6M3	
		8	Z-46M23	Z-36M18	Z-26M13	Z-20M10	Z-14M7	Z-10M5	Z-8M4	Z-6M3	
		10	Z-60M30	Z-50M25	Z-36M18	Z-24M12	Z-18M9	Z-12M6	Z-8M4	Z-6M3	
19.5		15	Z-90M30	Z-75M25	Z-54M18	Z-36M12	Z-27M9	Z-18M6	Z-12M4	Z-9M3	
26		20	Z-120M30	Z-100M25	Z-72M18	Z-48M12	Z-36M9	Z-24M6	Z-16M4	Z-12M3	
32.5	25	Z-150M30	Z-125M25	Z-90M18	Z-60M12	Z-45M9	Z-30M6	Z-20M4	Z-15M3		
6.5	Water	1	Z-11	Z-9	Z-7	Z-6	Z-4.5	Z-3.5	Z-2.5	Z-1.5	
		2	Z-23	Z-20	Z-13	Z-9	Z-7	Z-5	Z-3.5	Z-2.5	
		3	.	.	Z-25	Z-15	Z-10	Z-7	Z-4.5	Z-3.5	
		12.8	3	ZZ-23	ZZ-19	ZZ-14	ZZ-11	ZZ-8	ZZ-6	ZZ-4	ZZ-3
			4	ZZ-35	ZZ-27	ZZ-19	ZZ-13	ZZ-10	ZZ-7	ZZ-5	ZZ-3.5
5			.	ZZ-41	ZZ-25	ZZ-17	ZZ-12	ZZ-8	ZZ-6	ZZ-4	
6			.	.	ZZ-35	ZZ-22	ZZ-14	ZZ-10	ZZ-7	ZZ-4	
25.5		8	ZZ-70M35	ZZ-54M27	ZZ-38M19	ZZ-26M13	ZZ-20M10	ZZ-14M7	ZZ-10M5	ZZ-8M4	
		10	.	ZZ-82M41	ZZ-50M25	ZZ-34M17	ZZ-24M12	ZZ-16M8	ZZ-12M6	ZZ-8M4	
		12	.	.	ZZ-70M35	ZZ-44M22	ZZ-28M14	ZZ-24M12	ZZ-14M7	ZZ-8M4	
38.3		15	.	ZZ-123M41	ZZ-75M25	ZZ-51M17	ZZ-36M12	ZZ-24M8	ZZ-18M6	ZZ-12M4	
51		20	.	ZZ-164M41	ZZ-100M25	ZZ-68M17	ZZ-48M12	ZZ-32M8	ZZ-24M6	ZZ-16M4	
63.4		25	.	ZZ-205M41	ZZ-125M25	ZZ-85M17	ZZ-60M12	ZZ-40M8	ZZ-30M6	ZZ-20M4	
3	Silicone	1	X-3	X-2.5	X-2	X-1.5	X-1.5	X-1	X-0.75	X-0.5	
		2	X-5	X-4	X-3	X-2.5	X-2	X-1.5	X-1.0	X-0.75	
		3	X-6	X-5	X-4	X-3	X-2.5	X-2	X-1.5	X-1	
		4	X-9	X-7	X-5	X-4	X-3	X-2	X-1.5	X-1	
4.8		5	Y-11	Y-10	Y-7	Y-6	Y-4	Y-3	Y-2	Y-1.5	
		6	Y-14	Y-12	Y-9	Y-7	Y-5	Y-3.5	Y-2.5	Y-1.5	
		7	Y-18	Y-14	Y-10	Y-8	Y-6	Y-4	Y-3	Y-2	
		8	Y-23	Y-18	Y-12	Y-9	Y-6	Y-4.5	Y-3.5	Y-2.5	
9.5		10	Y-22M11	Y-20M10	Y-14M7	Y-12M6	Y-8M4	Y-6M3	Y-4M2	Y-4M2	
		12	Y-28M14	Y-24M12	Y-18M9	Y-14M7	Y-10M5	Y-8M4	Y-6M3	Y-4M2	
		16	Y-46M23	Y-36M18	Y-24M12	Y-18M9	Y-12M6	Y-10M5	Y-8M4	Y-6M3	
14.3		24	Y-69M23	Y-54M18	Y-36M12	Y-27M9	Y-18M6	Y-15M5	Y-12M4	Y-9M3	
19		32	Y-92M23	Y-72M18	Y-48M12	Y-36M9	Y-24M6	Y-20M5	Y-16M4	Y-12M3	
24		40	Y-115M23	Y-90M18	Y-60M12	Y-45M9	Y-30M6	Y-25M5	Y-20M4	Y-15M3	

Consult Factory

# Selection of Models

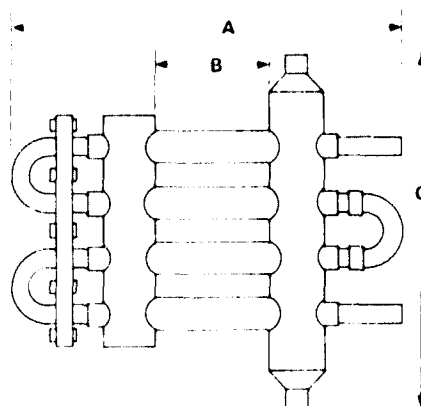
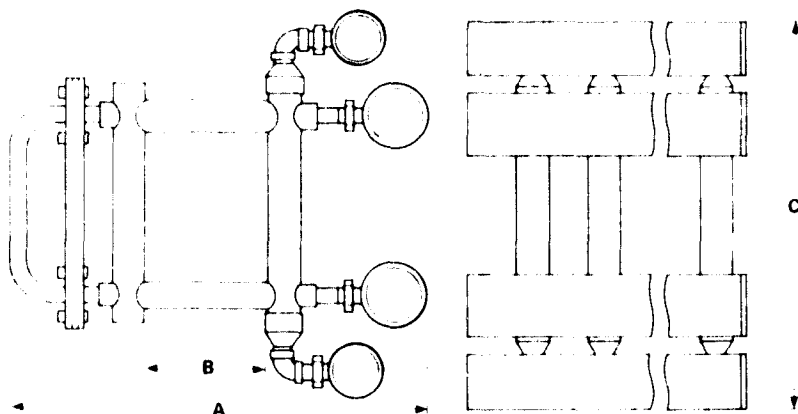
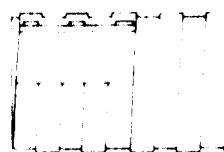
Surface area (sq ft.)	Model Identification					Total Lineal Feet				
	Number of Tubes					Heat Transfer Surface				
		4	6	8	10	X	Y	Z	ZZ	W
0.5	CS-0.5-2	(1) CSX-0.5-4				3.8	3.1	2.6		
0.75	CS-0.75-2	(2) CS-0.75-4	(1) CSX-0.75-6			5.7	4.6	3.8	2.9	
1.0	CS-1.0-2	(3) CS-1.0-4	(2) CS-1.0-6	(1) CSX-1.0-8		7.6	6.1	5.1	3.8	3.4
1.5	CS-1.5-2	CS-1.5-4	(4) CS-1.5-6	(3) CS-1.5-8	(2) CS-1.5-10	11.5	9.3	7.7	5.7	5.1
2.0	CS-2.0-2	CS-2.0-4	CS-2.0-6	(3) CS-2.0-8	(3) CS-2.0-10	15.3	12.3	10.2	7.6	6.8
2.5	CS-2.5-2	CS-2.5-4	CS-2.5-6	CS-2.5-8	(3) CS-2.5-10	19.1	15.4	12.8	9.5	8.5
3.0	CS-3.0-2	CS-3.0-4	CS-3.0-6	CS-3.0-8	(4) CS-3.0-10	22.9	18.5	15.3	11.5	10.2
3.5	CS-3.5-2	CS-3.5-4	CS-3.5-6	CS-3.5-8	CS-3.5-10	26.7	21.6	17.8	13.4	11.9
4.0	CS-4.0-2	CS-4.0-4	CS-4.0-6	CS-4.0-8	CS-4.0-10	30.5	24.7	20.4	15.3	13.6
4.5	CS-4.5-2	CS-4.5-4	CS-4.5-6	CS-4.5-8	CS-4.5-10	34.4	27.8	23.0	17.2	15.3
5.0	CS-5.0-2	CS-5.0-4	CS-5.0-6	CS-5.0-8	CS-5.0-10	38.2	30.9	25.5	19.1	16.9
6	(5) CS-6-2	CS-6-4	CS-6-6	CS-6-8	CS-6-10	45.6	37.0	30.6	22.9	20.3
7	(6) CS-7-2	CS-7-4	CS-7-6	CS-7-8	CS-7-10	53.4	43.2	35.7	26.7	23.7
8	(7) CS-8-2	CS-8-4	CS-8-6	CS-8-8	CS-8-10	61.1	49.4	40.8	30.6	27.1
9	(7) CS-9-2	CS-9-4	CS-9-6	CS-9-8	CS-9-10	68.7	55.6	45.9	34.4	30.5
10	(7) CS-10-2	CS-10-4	CS-10-6	CS-10-8	CS-10-10	76.3	61.7	51.0	38.2	33.9
11	(8) CS-11-2	(5) CS-11-4	CS-11-6	CS-11-8	CS-11-10	84.0	67.9	56.1	42.0	37.3
12		(5) CS-12-4	CS-12-6	CS-12-8	CS-12-10	91.6	74.1	61.2	45.8	40.7
13		(6) CS-13-4	CS-13-6	CS-13-8	CS-13-10	99.2	80.2	66.3	49.7	44.1
14		(6) CS-14-4	CS-14-6	CS-14-8	CS-14-10	106.9	86.4	71.4	53.5	47.5
15		(6) CS-15-4	CS-15-6	CS-15-8	CS-15-10	114.5	92.6	76.5	57.3	50.8
16		(7) CS-16-4	(5) CS-16-6	CS-16-8	CS-16-10	122.1	98.8	81.6	61.1	54.2
17		(7) CS-17-4	(5) CS-17-6	CS-17-8	CS-17-10	129.8	104.9	86.7	64.9	57.6
18		(7) CS-18-4	(5) CS-18-6	CS-18-8	CS-18-10	137.4	111.1	91.6	68.8	61.0
19		(7) CS-19-4	(5) CS-19-6	CS-19-8	CS-19-10	145.0	117.3	96.9	72.6	64.4
20		(7) CS-20-4	(6) CS-20-6	CS-20-8	CS-20-10	152.7	123.5	102.0	76.4	67.8
25			(7) CS-25-6	(5) CS-25-8	CS-25-10	190.8	154.2	127.5	95.5	84.7
30			(7) CS-30-6	(6) CS-30-8	(5) CS-30-10		185.0	153.0	114.6	101.7
35			(8) CS-35-6	(7) CS-35-8	(5) CS-35-10			178.5	133.7	118.6
40				(7) CS-40-8	(7) CS-40-10				152.8	135.6
45				(8) CS-45-8	(7) CS-45-10				171.9	152.5
50					(7) CS-50-10				191.0	169.5
55					(8) CS-55-10					186.4
C Dimension (inches)						A Dimension (inches)				
CSX	6 <sup>5</sup> / <sub>8</sub>	9 <sup>1</sup> / <sub>2</sub>	12 <sup>3</sup> / <sub>8</sub>	15 <sup>1</sup> / <sub>2</sub>	18 <sup>3</sup> / <sub>8</sub>	Divide total effective length in lineal feet by number of tubes then add				
CSX	6 <sup>5</sup> / <sub>8</sub>	9 <sup>1</sup> / <sub>2</sub>	12 <sup>3</sup> / <sub>8</sub>	15 <sup>1</sup> / <sub>2</sub>	18 <sup>3</sup> / <sub>8</sub>					
CSZ	6 <sup>5</sup> / <sub>8</sub>	9 <sup>1</sup> / <sub>2</sub>	12 <sup>3</sup> / <sub>8</sub>	15 <sup>1</sup> / <sub>2</sub>	18 <sup>3</sup> / <sub>8</sub>					
CSZZ	7 <sup>1</sup> / <sub>8</sub>	11 <sup>3</sup> / <sub>8</sub>	16 <sup>1</sup> / <sub>8</sub>	20 <sup>3</sup> / <sub>8</sub>	25 <sup>1</sup> / <sub>8</sub>					
CSW	9 <sup>1</sup> / <sub>8</sub>	15 <sup>3</sup> / <sub>8</sub>	21 <sup>3</sup> / <sub>8</sub>	27 <sup>3</sup> / <sub>8</sub>	33 <sup>3</sup> / <sub>8</sub>	7 <sup>1</sup> / <sub>8</sub>	6 <sup>1</sup> / <sub>8</sub>	6 <sup>3</sup> / <sub>8</sub>	7 <sup>3</sup> / <sub>8</sub>	8 <sup>1</sup> / <sub>8</sub>

Total Lineal Feet Heat Transfer Surface					
	X	Y	Z	ZZ	W
10	3.8	4.1	4.6	5.1	5.7
20	7.6	8.2	9.2	10.2	11.4
(2) 15-10	11.4	12.3	13.8	15.3	16.8
(3) 20-10	15.2	16.4	18.4	20.4	22.4
(3) 25-10	19.1	20.4	22.9	25.4	27.9
(4) 30-10	22.9	24.4	27.4	30.4	33.4
35-10	26.7	28.4	31.9	34.9	37.9
40-10	30.5	32.4	36.4	40.4	43.4
45-10	34.4	36.4	40.9	44.9	48.4
50-10	38.2	40.4	45.4	49.4	52.4
6-10	45.8	48.4	53.9	58.9	63.9
7-10	53.4	56.4	61.9	66.9	71.9
8-10	61.1	64.4	70.4	75.4	80.4
9-10	68.7	72.4	77.9	82.9	87.9
10-10	76.3	80.4	85.9	90.9	95.9
11-10	84.0	88.4	93.9	98.9	103.9
12-10	91.6	96.4	101.9	106.9	111.9
13-10	99.2	104.4	109.9	114.9	119.9
14-10	106.9	111.4	117.9	122.9	127.9
15-10	114.5	119.4	125.9	130.9	135.9
16-10	122.1	127.4	133.9	138.9	143.9
17-10	129.8	135.4	141.9	146.9	151.9
18-10	137.4	143.4	149.9	154.9	159.9
19-10	145.0	151.4	157.9	162.9	167.9
20-10	152.7	159.4	165.9	170.9	175.9
25-10	190.8	198.4	205.9	210.9	215.9
(5) 30-10	228.9	236.4	243.9	248.9	253.9
(6) 35-10	267.0	274.4	281.9	286.9	291.9
(7) 40-10	305.1	312.4	319.9	324.9	329.9
(7) 45-10	343.2	350.4	357.9	362.9	367.9
(7) 50-10	381.3	388.4	395.9	400.9	405.9
(8) 55-10	419.4	426.4	433.9	438.9	443.9

A Dimension (inches)

Divide total effective length in lineal feet by number of tubes, then add

6' 6" 6' 8" 6' 10" 7' 2" 7' 4"



Model numbers with M- in them have sections manifolded parallel to obtain proper flow characteristics.

Manifolds are sized for 4-4½ FPS velocity

**Example:** CSZ 25M5 model number means one unit with 25 square feet surface manifolded with 5 square foot sections; thus: 5 sections.

For approximate unit weight, multiply its square feet by:

CSX-10.8  
CSY-12.1  
CSZ-13  
CSZZ-15.6  
CSW-16.8

1. Available only in CSX Series
2. Available only in CSY and CSY Series
3. Not available in CSZZ and CSW Series
4. Not available in CSW Series
5. Not available in CSX Series
6. Not available in CSX or CSY Series
7. Available only in CSZZ or CSW Series
8. Available only in CSW Series

FOLDOUT FRAME 2



# CLEANABLE SOLAR HEAT EXCHANGERS with the VENTED DOUBLE WALL

- HIGH PERFORMANCE
- LONG OPERATING LIFE
- ALL COPPER CONSTRUCTION
- MAXIMUM COST EFFECTIVENESS

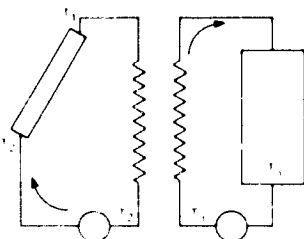
Doucette Cleanable Solar Heat Exchangers feature the vented double wall to preclude the possibility of solar fluid potable water cross contamination, and the cleanable all copper construction assures long life with continued high performance. The CSX, CSY, CSZ and CSZZ model heat exchangers are designed to control fluid velocities on both sides to insure maximum heat transfer in true counterflow, and improved collector efficiency. No other line of heat exchangers offers such a broad selection to meet specific design criteria, from small domestic hot water systems to large industrial or commercial systems.

The selection of the proper heat exchanger for a specific application is relatively easy, if the desired minimum operating conditions are well defined. The critical factor in sizing the heat exchanger to a given application is the collector rise factor, CRF, defined as the ratio of the temperature rise across the collector to the difference between the temperature of the solar fluid leaving and the water temperature entering the heat exchanger, in units of F/F. The CRF defines the operating temperature of the collector for any given water entering temperature, and therefore determines the operating efficiency of the collector. The CRF should be held as low as possible within economic limits to insure maximum performance from the collector.

The minimum operating conditions define the CRF and the required heat exchanger effectiveness. The number and kind of collector defines the solar fluid as its volume flow rate. From the Table on the reverse side, it is possible to pick a specific heat exchanger model and it requires water recirculation rate. Interpolation to other conditions and other models is possible for estimation purposes.

## MODEL

$$CRF = \frac{T_2 - T_1}{T_3 - T_2}$$



## EXAMPLE

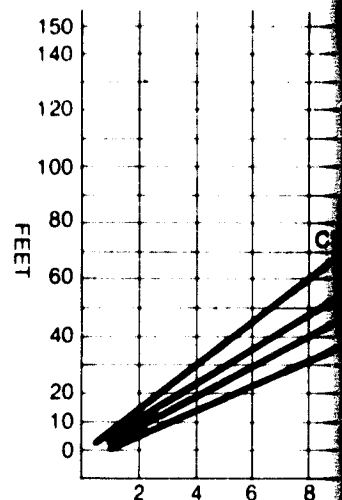
$T_1$  153 F  
 $T_2$  130 F  
 $T_3$  120 F  
 $T_2 - T_1$  10 F  
 $T_3 - T_2$  23 F

$$CRF = \frac{10 \text{ F}}{23 \text{ F}} = 0.43$$

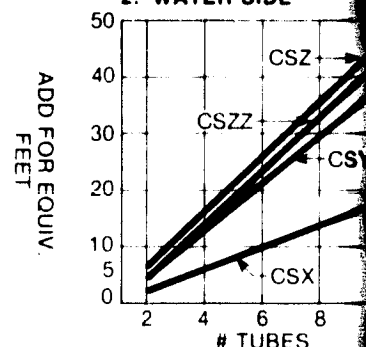
$$\text{Effectiveness Required} = \frac{T_1 - T_2}{T_1 - T_3} = 0.70$$

FOLDOUT FRAME

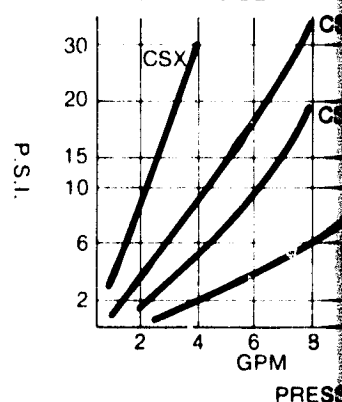
## 1. LENGTH OF SURFACE



## 2. WATER SIDE



## 4. WATER SIDE

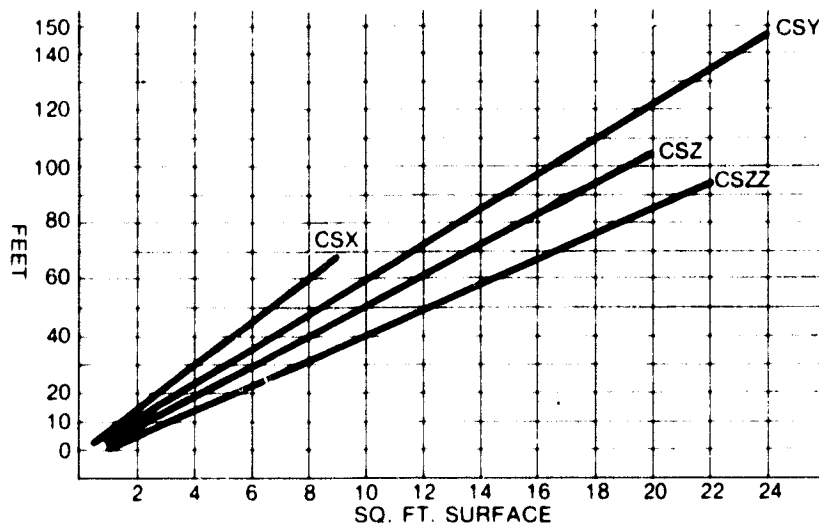


## To read curves:

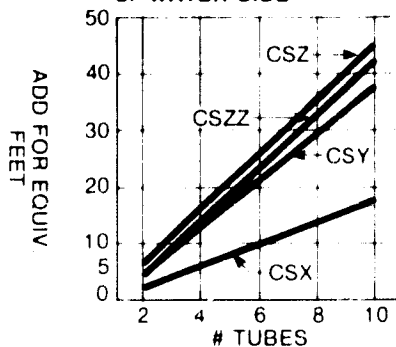
1. Select unit model from the chart.
2. Lineal feet from curve No. 1.
3. Add equivalent feet from curve No. 2

DISTRIBUTED BY

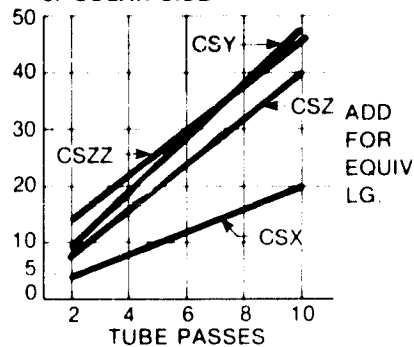
# 1. LENGTH OF SURFACE TUBE



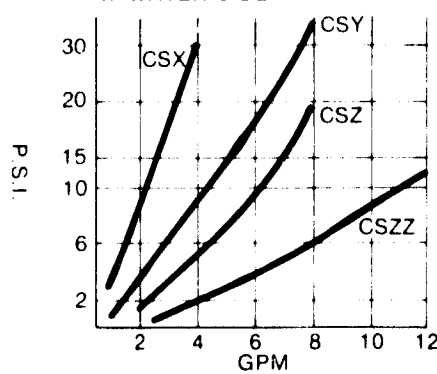
## 2. WATER SIDE



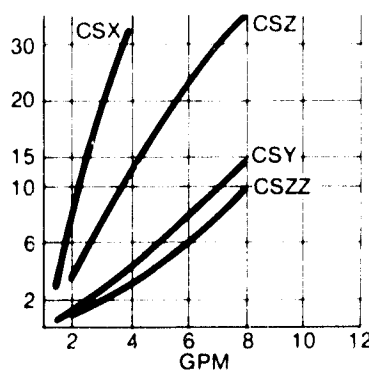
## 3. SOLAR SIDE



## 4. WATER SIDE



## 5. SOLAR SIDE



PRESSURE DROP PSI PER 100 FEET

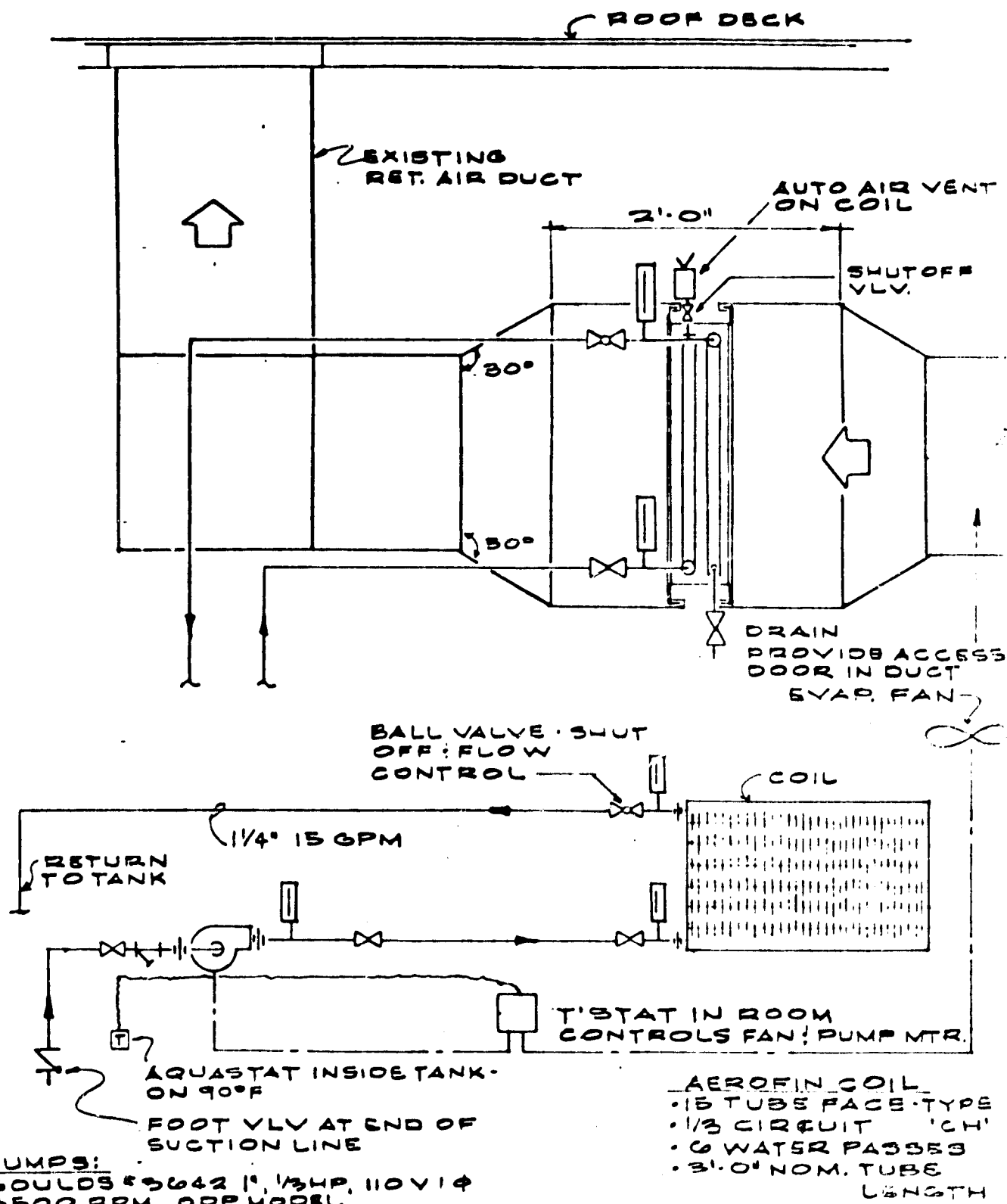
### To read curves:

1. Select unit model from the chart.
2. Lineal feet from curve No. 1.
3. Add equivalent feet from curve No. 2 or No. 3.
4. Curves No. 4 and 5 are pressure drop in PSI per 100 feet.
5. If pressure drop is excessive, additional sections can be added but with a consequent reduction in effectiveness.

**doucette industries, inc.**  
"INNOVATORS OF THE VENTED DOUBLE WALL"

P. O. Box 1641, York, PA 17405 • 717-845-8746

# TYPICAL HYDRONIC COIL PIPING DETAIL

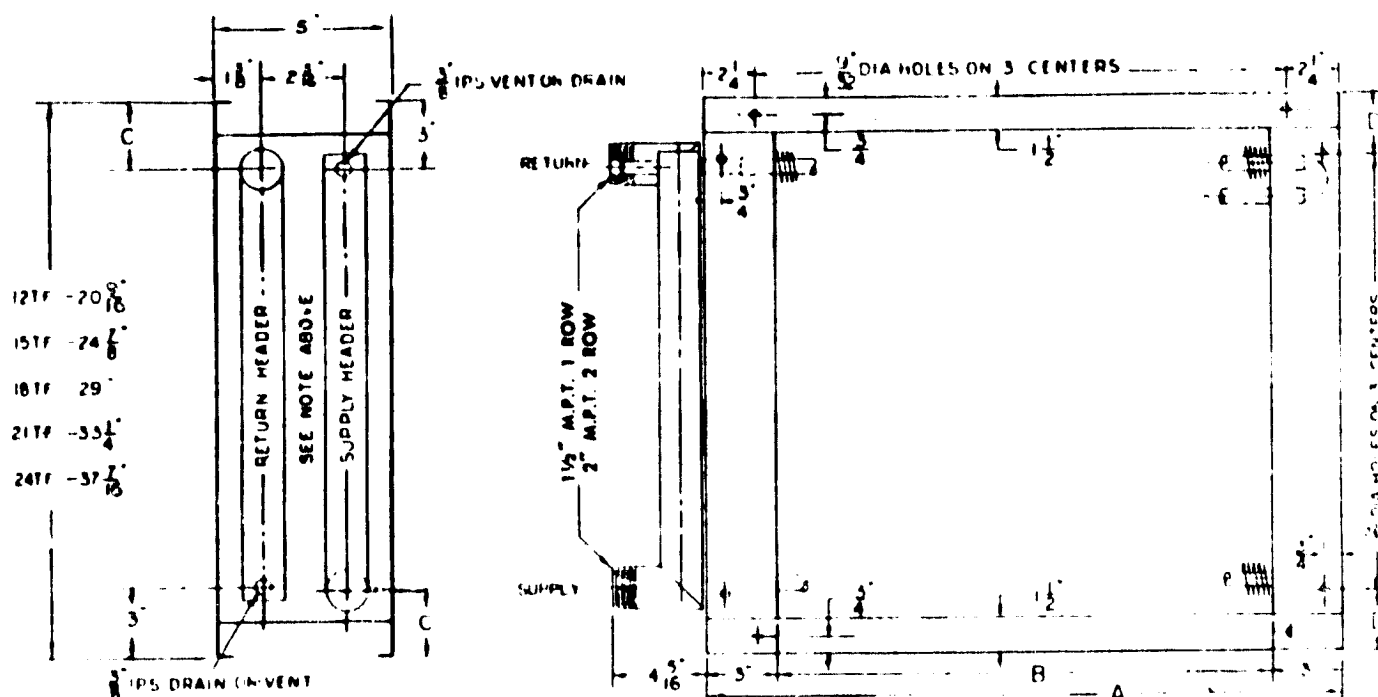


DATE:	6-20-77	DAVID C. WILSON HOSPITAL	
DRAWN BY:	EW	SOLAR SYSTEM RETROFIT	
APPROVED BY:	JO	OWEN! MAYES, INC.	
		LYNCHBURG	
		VIRGINIA	
		NUMBER:	1 OF 2
		SCALE:	1:1

## TYPE CH

**All dimensions approximate. Certified drawings upon request.**

ON 2 ROW COIL  
CONNECTIONS SHOWN FOR  
AIRFLOW LEFT TO RIGHT.  
FOR AIRFLOW RIGHT TO LEFT  
ROTATE COIL 180°



**TABLE 1 — 12, 15, 18, 21 and 24 Tube Face**

Nominal Tube Length	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"
A	2'-4 1/2"	2'-10 1/2"	3'-4 1/2"	3'-10 1/2"	4'-4 1/2"	4'-10 1/2"	5'-4 1/2"	5'-10 1/2"	6'-4 1/2"	6'-10 1/2"	7'-4 1/2"	7'-10 1/2"	8'-4 1/2"	8'-10 1/2"	9'-4 1/2"	9'-10 1/2"	10'-4 1/2"
B	22 1/2"	23 1/2"	34 1/2"	40 1/2"	45 1/2"	52 1/2"	58 1/2"	64 1/2"	70 1/2"	76 1/2"	82 1/2"	88 1/2"	94 1/2"	100 1/2"	106 1/2"	112 1/2"	118 1/2"

### TABLE 2

Tube Force	C		D
	1 Row	2 Row	
12	2 1/4"	2 1/8"	4 1/8"
15	2 1/4"	2 3/8"	3 1/8"
18	2 1/4"	2 3/8"	2 1/4"
21	2 1/4"	2 1/8"	4 1/8"
24	2 1/4"	2 1/8"	3 1/8"

**TABLE No. 3** NUMBER OF WATER CIRCUITS AND PASSES

AEROFIN CIRCUIT DESIGNATION	NUMBER OF WATER CIRCUITS							NUMBER OF WATER PASSES	
	12	15	18	21	24	27	30	1 ROW	2 ROW
FULL	12	15	18	21	24	27	30	--	2
ONE HALF	6	8	9	11	12	14	15	2	4
ONE THIRD	4	5	6	7	8	9	10	4	6
ONE FOURTH	3	4	5	6	6	7	8	4	--

**TABLE No. 4 — Face Area (Square Feet)**

OVERALL HEIGHT	TUBE FACE	NOMINAL TUBE LENGTH																	
		2'-0	2'-6	3'-0	3'-6	4'-0	4'-6	5'-0	5'-6	6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0	
20'-0	12	2.63	3.34	4.04	4.74	5.45	6.15	6.85	7.55	8.26	8.96	9.66	10.36	11.07	11.77	12.47	13.17	13.88	
24'-0	15	3.29	4.16	5.04	5.92	6.79	7.67	8.55	9.42	10.30	11.18	12.05	12.93	13.81	14.68	15.56	16.44	17.31	
29'-0	18	3.94	4.99	6.04	7.09	8.14	9.19	10.24	11.29	12.34	13.39	14.44	15.49	16.54	17.59	18.64	19.70	20.75	
33'-0	21	4.59	5.82	7.04	8.26	9.49	10.71	11.94	13.16	14.39	15.61	16.83	18.06	19.28	20.51	21.73	22.96	24.18	
37'-0	24	5.24	6.64	8.04	9.44	10.84	12.23	13.63	15.03	16.43	17.83	19.22	20.62	22.02	23.42	24.82	26.22	27.61	

FACE AREAS MAY BE EXTRAPOLATED FOR SPECIAL 27 AND 30 TUBE FACE AND NOMINAL  
TUBE LENGTHS UP TO AND INCLUDING 12'0" IN 6" INCREMENTS

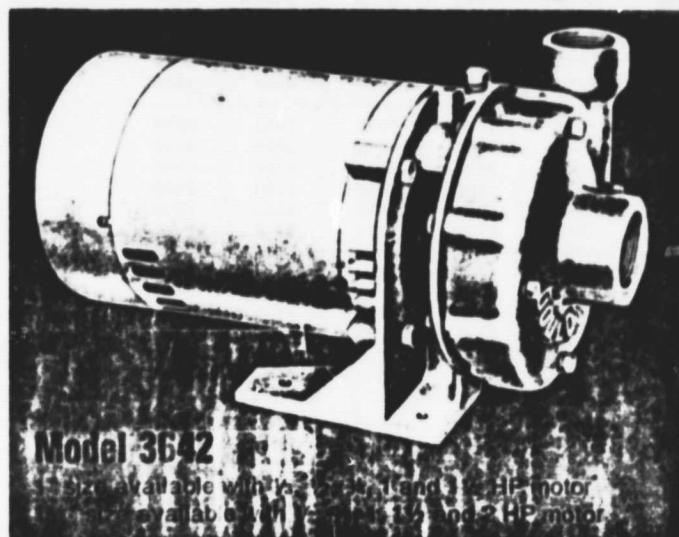
TABLE No.5 Volume of Air (CFM) To Be Passed Through Coil Type "CH"

Overall Casing Width	Tube Face	Face Velocity	NOMINAL TUBE LENGTH								
			2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"
20 1/4"	12	300	780	990	1200	1410	1620	1830	2040	2250	2460
		400	1040	1320	1600	1880	2160	2440	2720	3000	3290
		500	1300	1630	2000	2350	2700	3050	3400	3750	4100
		600	1560	1980	2400	2820	3240	3660	4080	4500	4920
		700	1820	2310	2800	3290	3780	4270	4760	5250	5740
		800	2080	2640	3200	3760	4320	4880	5440	6000	6560
24 1/4"	15	300	990	1230	1500	1770	2040	2310	2580	2820	3090
		400	1320	1640	2000	2360	2720	3080	3440	3760	4120
		500	1630	2050	2500	2950	3400	3850	4300	4700	5150
		600	1980	2460	3000	3540	4080	4620	5160	5640	6180
		700	2310	2870	3500	4130	4760	5390	6020	6580	7210
		800	2640	3280	4000	4720	5440	6160	6880	7520	8240
29"	18	300	1200	1500	1830	2130	2460	2760	3090	3390	3720
		400	1600	2000	2440	2840	3280	3680	4120	4520	4960
		500	2000	2500	3050	3550	4100	4600	5150	5650	6200
		600	2400	3000	3660	4260	4920	5520	6180	6780	7440
		700	2800	3500	4270	4970	5740	6440	7210	7810	8680
		800	3200	4000	4880	5680	6560	7360	8240	9040	9920
33 1/4"	21	300	1380	1740	2130	2490	2850	3240	3600	3960	4320
		400	1840	2320	2840	3320	3800	4320	4800	5280	5760
		500	2300	2900	3550	4150	4750	5400	6000	6600	7200
		600	2760	3480	4260	4980	5700	6480	7200	7920	8640
		700	3220	4060	4970	5810	6650	7560	8400	9240	10080
		800	3680	4640	5680	6640	7600	8640	9600	10560	11520
37 1/4"	24	300	1590	2010	2430	2850	3270	3690	4110	4530	4950
		400	2120	2680	3240	3800	4360	4920	5480	6040	6600
		500	2650	3350	4050	4750	5450	6150	6850	7550	8250
		600	3180	4020	4760	5700	6540	7380	8220	9060	9900
		700	3710	4690	5670	6650	7630	8610	9590	10570	11550
		800	4240	5360	6480	7600	8720	9840	10960	12080	13200

Overall Casing Width	Tube Face	Face Velocity	NOMINAL TUBE LENGTH							
			6'6"	7'0"	7'6"	8'0"	8'6"	9'0"	9'6"	10'0"
20 1/4"	12	300	2670	2910	3120	3330	3540	3750	3960	4170
		400	3560	3880	4160	4440	4720	5000	5280	5560
		500	4450	4850	5200	5550	5900	6250	6600	6950
		600	5340	5820	6240	6660	7080	7500	7920	8340
		700	6230	6790	7280	7770	8260	8750	9240	9730
		800	7120	7760	8360	8880	9440	10000	10560	11120
24 1/4"	15	300	3360	3630	3900	4140	4410	4680	4950	5190
		400	4480	4840	5200	5520	5880	6240	6600	6920
		500	5600	6050	6500	6900	7350	7800	8250	8650
		600	6720	7260	7800	8280	8720	9360	9900	10380
		700	7840	8470	9100	9660	10290	10920	11550	12110
		800	8960	9680	10400	11040	11760	12480	13200	13840
29"	18	300	4020	4350	4650	4980	5310	5610	5910	6240
		400	5360	5800	6200	6640	7080	7480	7880	8320
		500	6700	7250	7750	8300	8850	9350	9850	10400
		600	8040	8700	9300	9960	10620	11220	11820	12480
		700	9380	10150	10850	11620	12390	13090	13790	14560
		800	10720	11600	12400	13280	14160	14960	15760	16640
33 1/4"	21	300	4710	5070	5430	5820	6180	6540	6900	7290
		400	6280	6760	7240	7760	8240	8720	9200	9720
		500	7850	8450	9050	9700	10300	10900	11500	12150
		600	9420	10140	10860	11640	12360	13080	13800	14580
		700	10990	11830	12670	13580	14420	15260	16100	17010
		800	12560	13520	14480	15520	16480	17440	18400	19440
37 1/4"	24	300	5370	5790	6210	6630	7050	7470	7890	8310
		400	7160	7720	8280	8840	9400	9960	10520	11080
		500	8950	9650	10350	11050	11750	12450	13150	13850
		600	10740	11580	12420	13260	14100	14940	15780	16620
		700	12530	13510	14490	15470	16450	17430	18410	19390
		800	14320	15440	16560	17680	18800	19920	21040	22160

# Models 3642 & 3656

## Close-Coupled Centrifugal Pumps



**Designed for General Purpose Pumping, Water, Process and Transfer**

- Capacities to 390 GPM (89 m<sup>3</sup>/h)
- Heads to 275 feet (84 m)
- Temperatures to 250°F (121°C)
- Pressures to 120 PSIG (828 kPa)

### Design Features

- Close-Coupled Construction
- Eight Position casing (Four on 3656)
- Compact Design
- Simple Installation
- Quiet Operation
- Mechanical Seal
- Single Stage, Enclosed Impeller

**ORIGINAL PAGE IS  
OF POOR QUALITY**

### Specifications

**Casing** Volute type, bolted to adapter with recessed lock fit to assure alignment. Top vertical discharge is standard assembly. Tapped opening provides for priming, venting, draining, and suction and discharge connections. Vertically split casing allows inspection without disturbing piping connections.

**Impeller** Enclosed, single suction type, cast in one piece. Model 3642 impellers are threaded on extended motor shaft, further secured by stainless steel jamnut. Model 3656 impellers are keyed to motor shaft, secured by stainless steel impeller screw.

**Adapter** Maintains rigid assembly between casing and motor end bracket. Model 3642 mounting feet are integral with adapter. Model 3656 motors are foot mounted and motor supports pump unit.

**Rotation** All pumps are right hand i.e., clockwise rotation viewed from motor.

**Mechanical Seal** Suitable for water to 212°F and hydrocarbons.

**Motor** Assembled as an integral part of unit. All motors have ball bearings.

Model 3642 motors have NEMA standard end brackets and shaft extension. Shaft is 416 stainless steel. Single phase open motors have built in overload protection. Open, enclosed and explosion proof motor enclosures available.

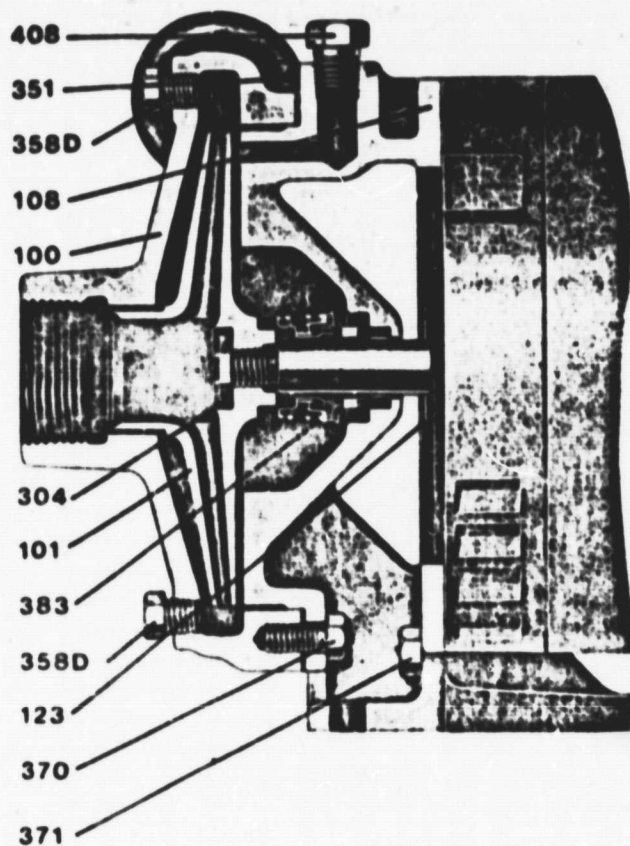
Model 3656 motors have NEMA standard end brackets, standard JM shaft extension and feet. Shaft extension is carbon steel, fully protected by a shaft sleeve.

Available in open, enclosed and explosion proof enclosures through 15 HP, single and three phase.

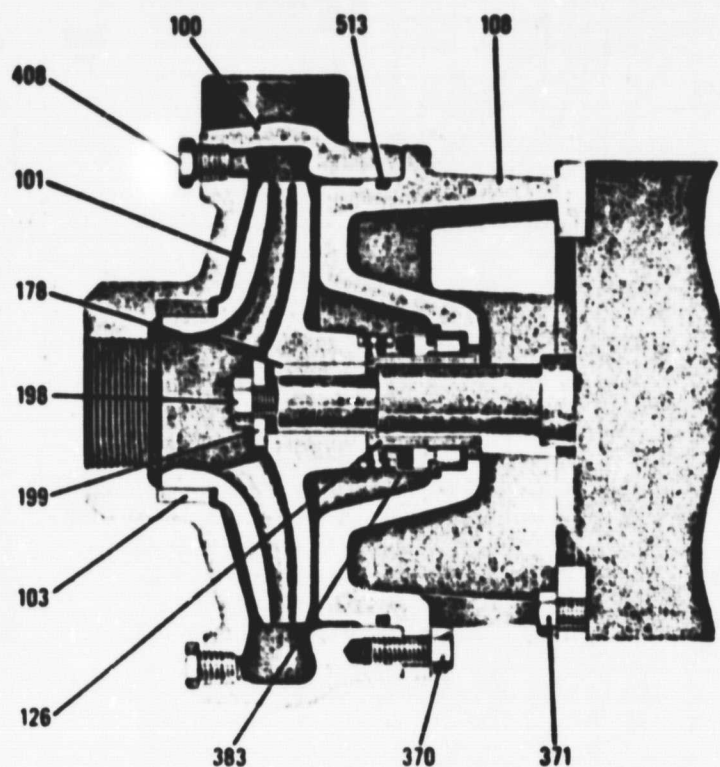
**Materials of Construction** Model 3642 and 3656 are available in bronze fitted, all iron, or all bronze.

# Sectional View

Model 3642



Model 3656



## Parts List and Materials of Construction

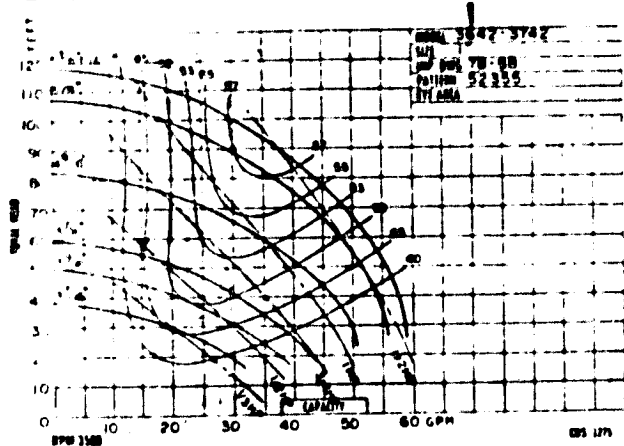
Item No.	Part Name	Material					
		Model 3642			Model 3656		
		Bronze Fitted	All Iron	All Bronze	Bronze Fitted	All Iron	All Bronze
100	Casing	1001	1001	1102	1001	1001	1102
101	Impeller	1102	1001	1102	1102	1001	1102
103	Casing Wearing Ring	(Not Required)			1102	1001	1102
108	Adapter	1101	1001	1102	1001	1001	1102
123	Deflector	Formica			N.A.		
126	Shaft Sleeve	(Not Required)			18-8 Stainless Steel		
178	Impeller Key	(Not Required)			18-8 Stainless Steel		
198	Impeller Bolt	(Not Required)			18-8 Stainless Steel		
199	Impeller Washer	(Not Required)			18-8 Stainless Steel		
304	Impeller Nut	14% Chrome Steel (AISI 416)			(Not Required)		
351	Casing Gasket	Asbestos			(Not Required)		
358D	Pipe Plug (1/4")	Steel	Steel	Brass	(Not Required)		
370	H Cap Screw	Steel			Steel		
371	H Cap Screw, Adapter-to-Motor	Steel			Steel		
383	Mechanical Seal	JC Type 6 (1/4") B/N P66 171			JC Type 21 (1/4")		
408	Pipe Plug—1/4"	Steel	Steel	Brass	Zinc Chr. Plated Steel		1102
513	O-ring—1/8"	(Not Required)			Buna N		

Code	Specification
1001	Cast Iron (No ASTM Code)
1102	Bronze — ASTM B584-4A CA 836

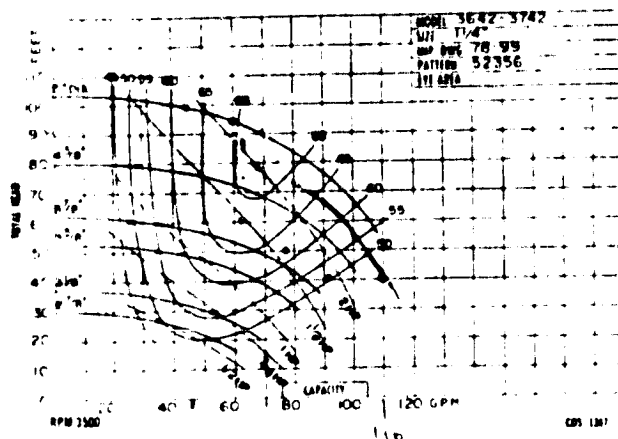
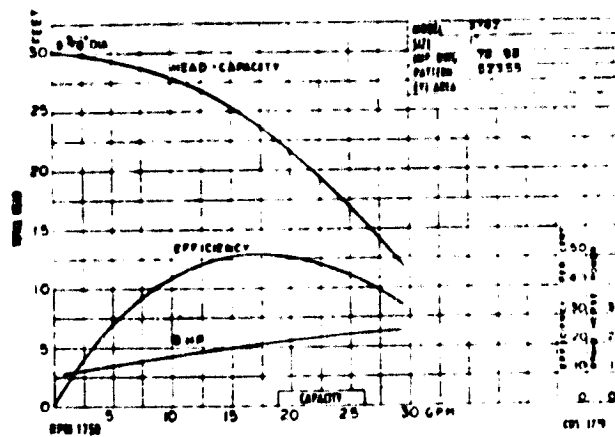
1000—Cast Iron ASTM A48 Class 25



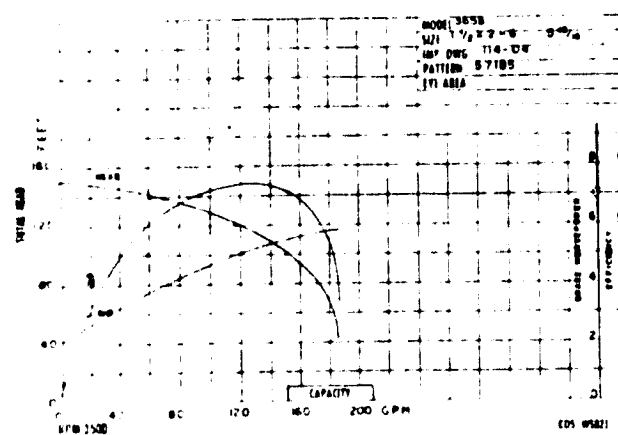
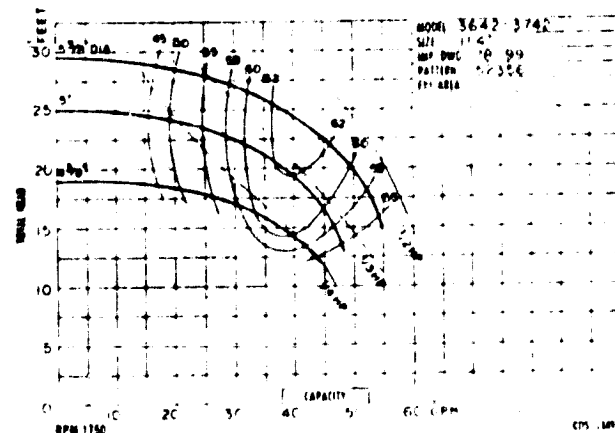
# Performance Curves Models 3642 & 3656



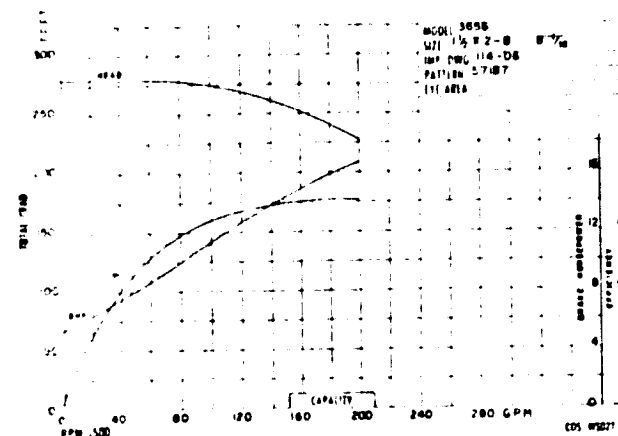
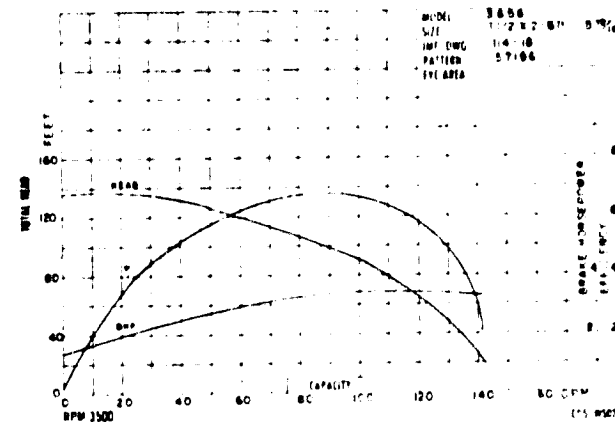
3642  
1"



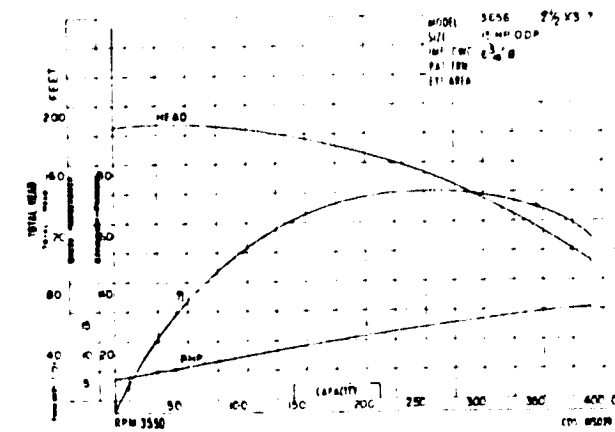
3642  
1 1/4"



3656



3656



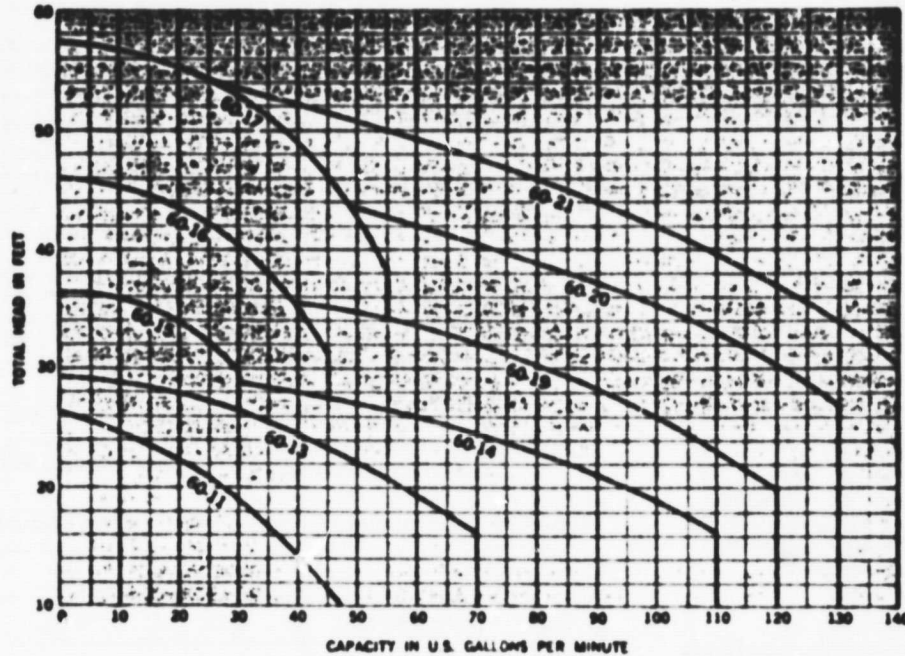




# B&G Series 60 Centrifugal Pumps

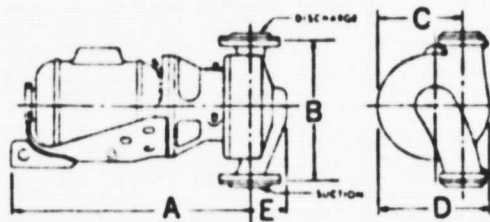
Bronze fitted construction—equipped with 1750 RPM, 60 cycle, drip-proof motors and companion flanges. 60-11S, 13S, 13T, 14S, 14T also available in all bronze construction. Add "B" to unit number when ordering. Built-to-order units are available when conditions cannot be met by stock pump selections.

## Selection Chart



Add "S" to pump number when ordering single phase pumps.

Add "T" to pump number when ordering three phase pumps.



### STANDARD VOLTAGES

¼ HP, 1 PH, 115 Volts.  
½ to 1½ HP, 1 PH, 115/230 Volts.  
¼ to ¾ HP, 3 PH, 208-230/460 Volts.  
1 to 2 HP, 208 or 230/460 Volts.  
All single phase motors have built-in overload protection.

## Dimensions

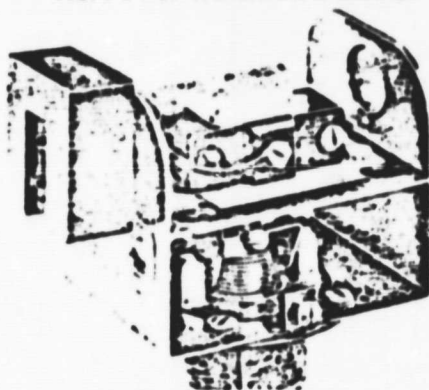
UNIT NO.	PUMP SIZE	MOTOR H.P.	APPROXIMATE DIMENSIONS IN INCHES NOT TO BE USED FOR INSTALLATION				
			A	B	C	D	E
60-11	1¼AA	¼	15½	11	5	7½	3¾
60-13	1¼AA	½	17½	11½	5½	7¾	3¾
60-14	2AA	¾	18½	11½	5½	8	3¾
60-15	1½A	½	21¼	13½	5½	9½	3¾
60-16	1½A	¾	21¼	13½	5½	9½	3¾
60-17	1½A	1	19¾	13½	5½	9½	3¾
60-19	2A	1	19¾	14	5½	9¾	3½
60-20	2A	1½	20¾	14	5½	9¾	3½
60-21	2A	2	21¾	14	5½	9¾	3½

# McDONNELL No. FS4-3F and No. FS4-3F-20 WATER FLOW INDICATORS



- Maximum working pressure, 150 psi.
- Packed shipping weight, 3 lbs.

No. FS4-3F Waterflow Indicator



No. FS4-3F-20 Waterflow Indicator includes solid state 20-second time delay.

## Underwriters' Laboratories Listed for Service on Distribution or Branch Piping of Fire Sprinkler Systems

These McDonnell Waterflow Indicators provide an economical and positive way of detecting the flow of water in any distribution or branch piping of a fire sprinkler system. Connected electrically to various types of alarm or signal devices, they immediately indicate exactly where any sprinkler head or heads are open.

This quick detection and notification pinpoints the location of the fire, speeds up the ability to extinguish the fire, assists in safe evacuation of the premises, and minimizes the amount of water damage.

The No. FS4-3F and No. FS4-3F-20 have the same design, construction and operation, except the No. FS4-3F-20 includes a solid state time delay. This provides a factory-fixed 20-second delay on make to prevent false alarms which might be caused by brief movements of water due to variations in system pressure, temporary surges or water hammer. Time delay is 100% encapsulated, mounts directly on switch housing. Input—115 volt A.C.; Output—1 ampere RMS steady state maximum, 20 milliamperes minimum.

Note: Many sprinkler systems also employ the use of a large primary Waterflow Indicator equipped with a time retard mechanism and installed where the main water supply is connected to the sprinkler system. The No. FS4-3F is not intended for this purpose. The No. FS4-3F is used only in the distribution of branch systems (sometimes referred to as "partial systems").

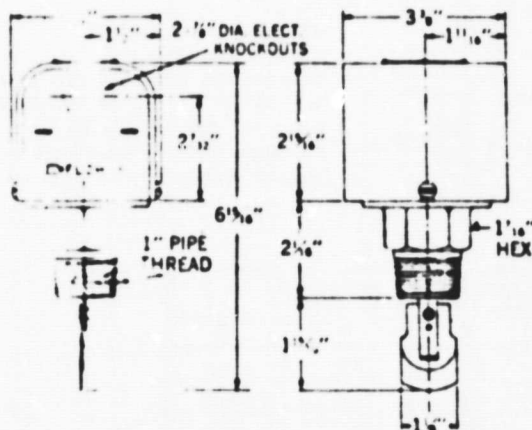
ELECTRICAL RATINGS (Underwriters Listed)	SWITCH	7.4 Amps	115 Volts A.C.
		3.7 Amps	230 Volts A.C.
		0.3 Amps	6-125 Volts D.C.

### Flow Rates Required to Actuate Waterflow Indicators

Pipe Size	1"	1 1/4"	1 1/2"
Flow Required (GPM)	6.0	9.8	12.7

Flow rates are averages which may vary  $\pm 10\%$  from tabulated values.

### Dimension Details No. FS4-3F Flow Switch



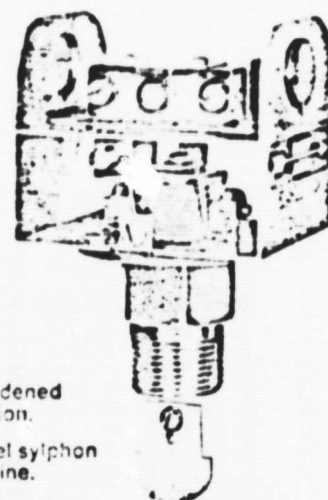
**Easy Wiring** — Cover completely removable. No cramped quarters, no danger of kinked wires interfering with operation.

**Two Knockouts** — Connect conduit at either side of housing.

**Switch** — single pole, double throw. Compact in size. Powerful snap action assures dependable operation.

**Knife-Edged Bearings** of hardened stainless steel minimize friction.

**Packless** — Heavy duty monel syphon seals switch assembly from line.



## McDONNELL & MILLER ITT

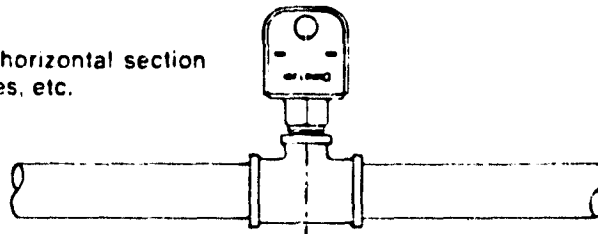
3500 N. Spaulding Avenue, Chicago, Illinois 60618  
Tel: (312) 267-1600

## INSTALLATION DATA

### No. FS4-3F and No. FS4-3F-20 WATERFLOW INDICATORS

#### LOCATION:

The Waterflow Indicator should be located in a horizontal section of pipe. Avoid locations adjacent to elbows, valves, etc.

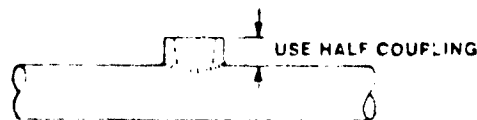
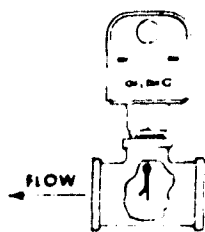


#### INSTALLATION:

Adjust the Waterflow Indicator paddle to the size of pipe in which it is to be used.

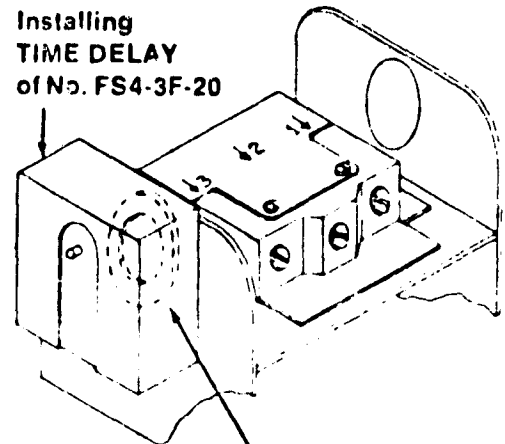
If a reducing tee is not available, and a standard tee is used, install a face or hex bushing in top opening to keep Waterflow Indicator as close to pipe as possible.

If the Waterflow Indicator is connected to the pipe by a welding fitting, select a welding fitting of minimum length, such as a HALF COUPLING.



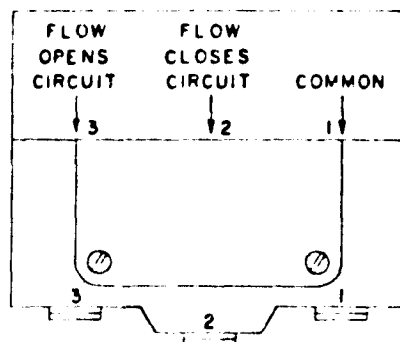
Screw the Waterflow Indicator in position so that the paddle is at right angles to the flow, and the arrow mark on side is same as direction of flow.

#### Installing TIME DELAY of No. FS4-3F-20

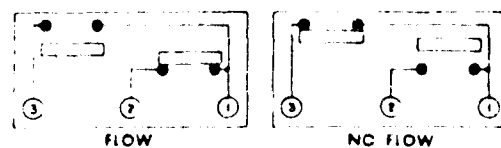


Place space washer (furnished) on threaded stem before attaching through knockout opening with locknut (furnished). There is no polarity involved, either lead wire from time delay may be connected to electrical circuit.

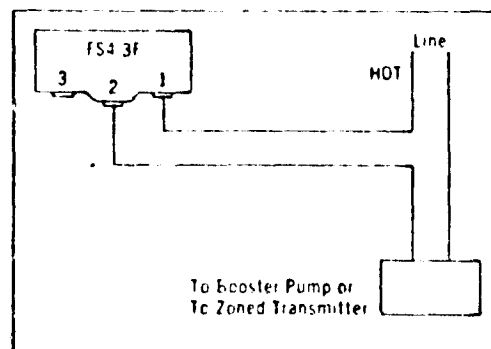
#### ELECTRICAL



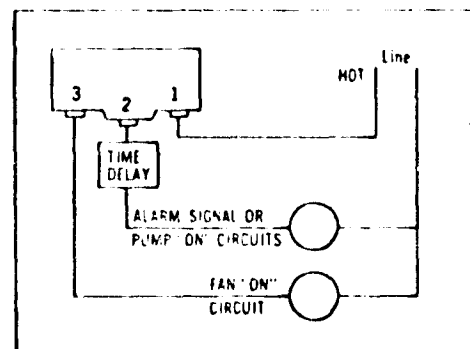
#### Schematic of Flow Switch Operation



#### TYPICAL WIRING



1. To actuate water sprinkler booster pump or zoned transmitter.

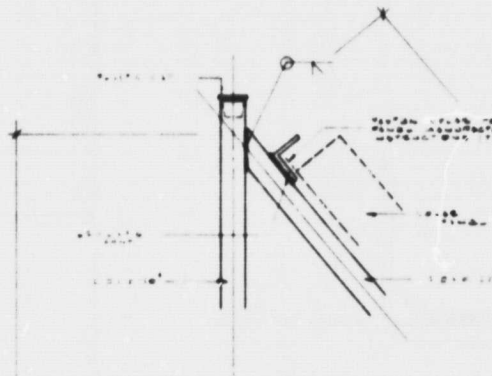


2. To wire time delay of No. FS4-3F-20 into circuits controlling alarm, signal or pump.

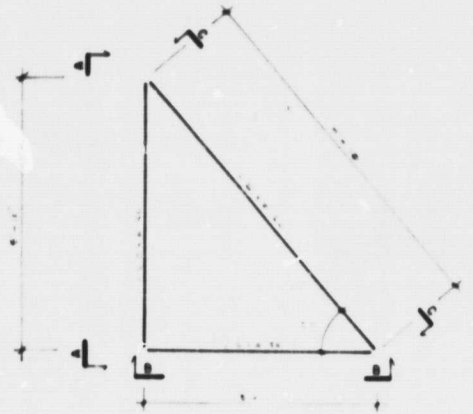
APPENDIX B  
DESIGN DRAWINGS

Note: Drawings are best available. Some of the drawings show the 2 stage heat pump which was never installed.

ORIGINAL PAGE IS  
OF POOR QUALITY

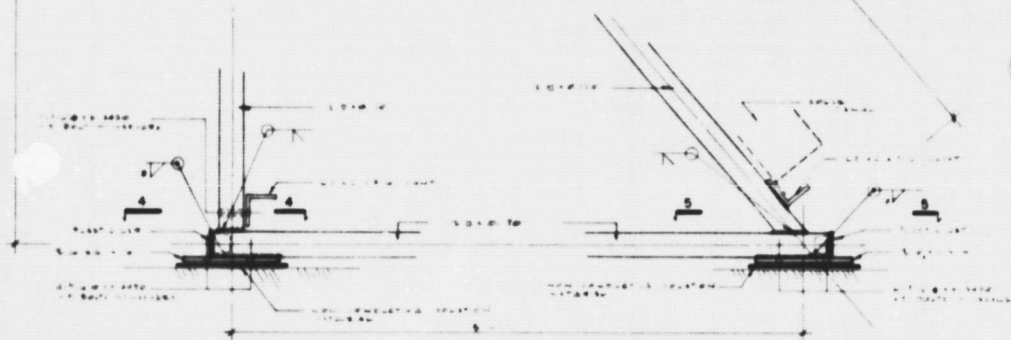


JOINT DETAIL "A"

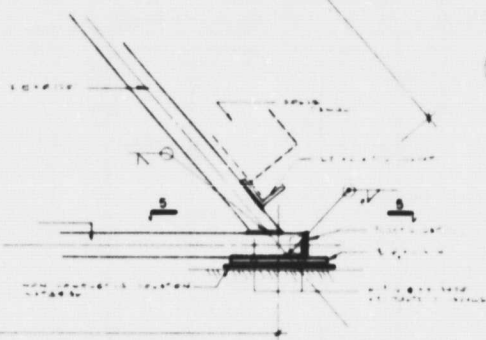


FRAME ELEVATION

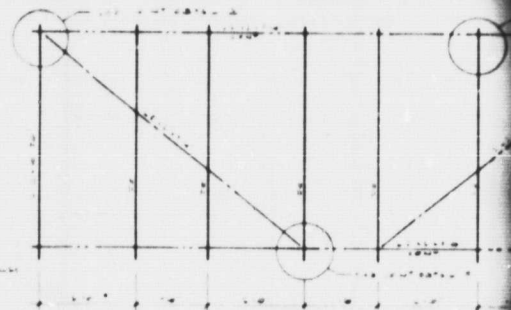
DESIGN LOADS  
20 PSF SNOW  
20 PSF WIND



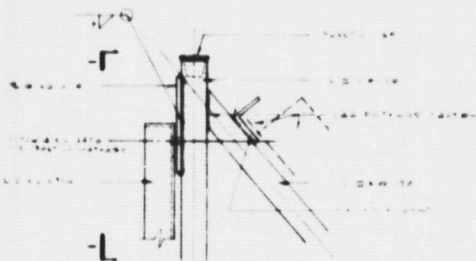
JOINT DETAIL "C"



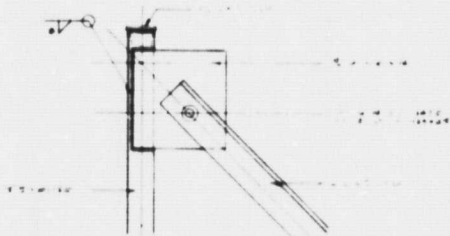
JOINT DETAIL "B"



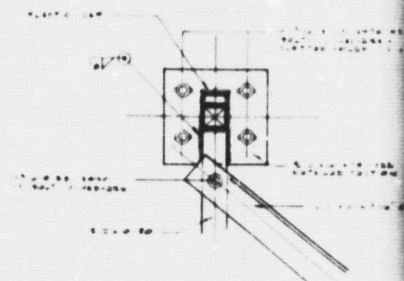
ELEVATION B-B



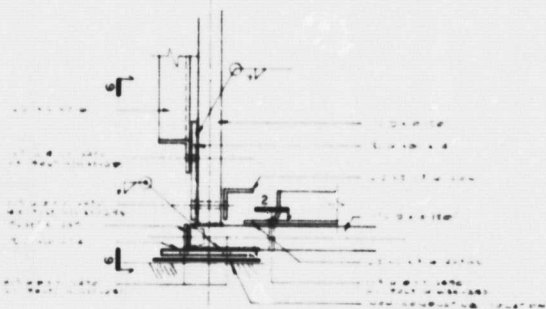
JOINT DETAIL "D"



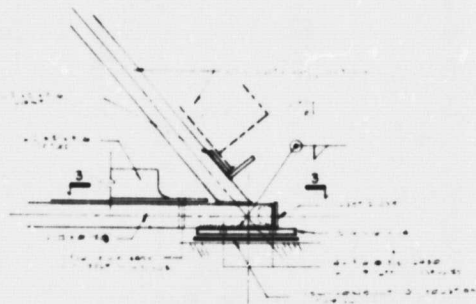
SECTION 1-1



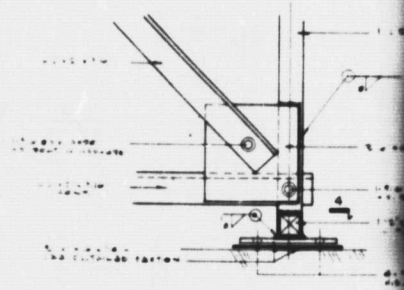
SECTION 2-2



JOINT DETAIL "E"

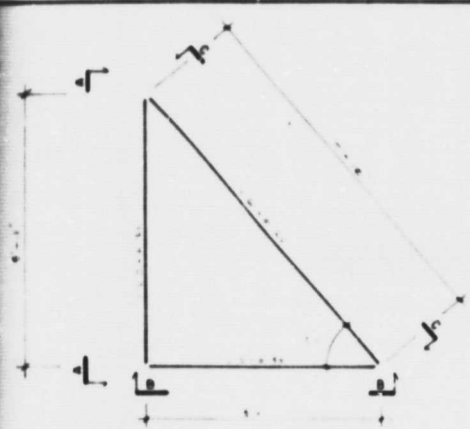


JOINT DETAIL "F"



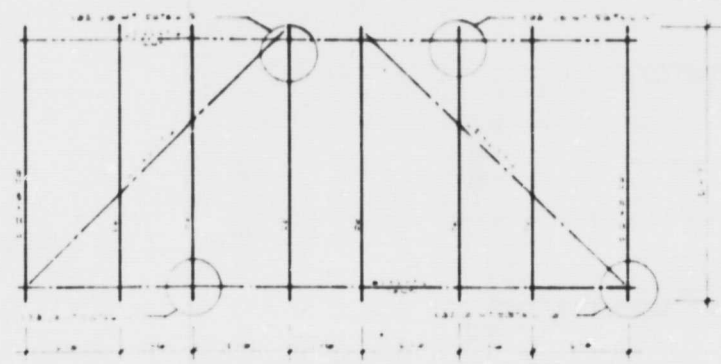
SECTION 6-6



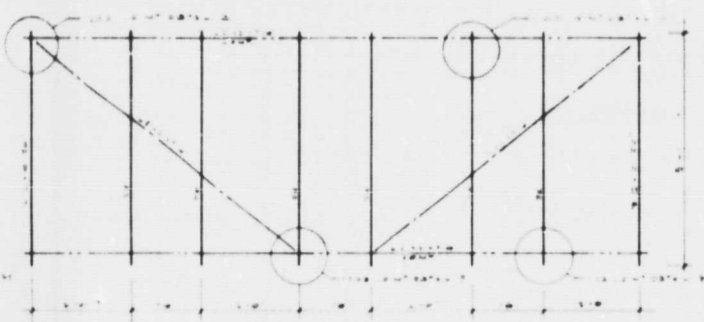


FRAME ELEVATION

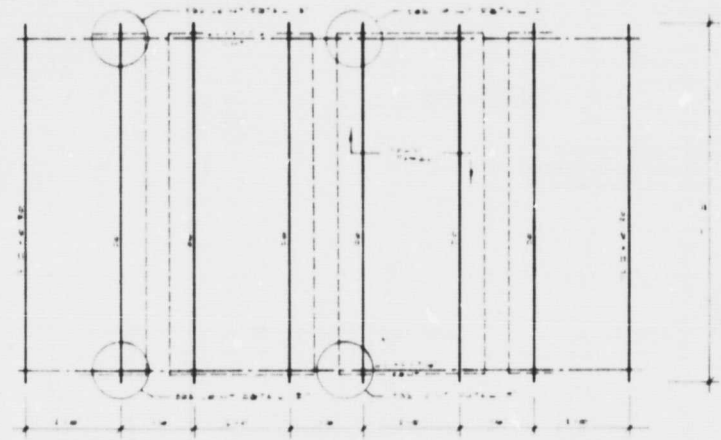
DESIGN LOADS  
20 PSF SNOW  
20 PSF WIND



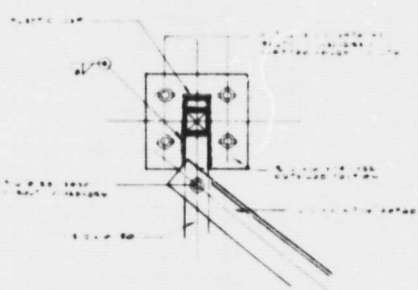
ELEVATION P - A



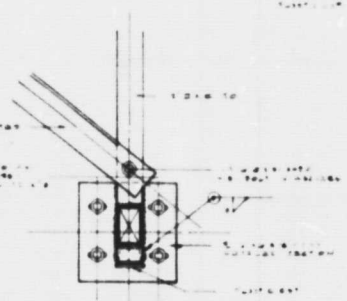
ELEVATION B - B



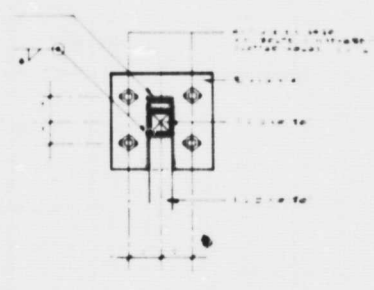
ELEVATION C - C



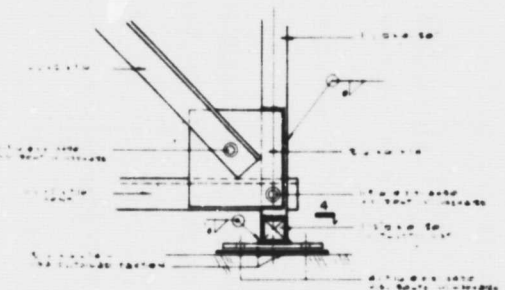
SECTION 2 - 2



SECTION 3 - 3



SECTION 4 - 4  
SECTION 5-5 SIMILAR



SECTION 6 - 6

ALL DIMENSIONS AND DETAILS SHOWN ON THIS SET OF DRAWINGS SHALL BE TAKEN  
VERIFIED AND COORDINATED BY THE DESIGNER PRIOR TO CONSTRUCTION.  
DETAILS SHOWN IN ANY SECTION APPLY TO ALL SECTIONS UNLESS OTHERWISE NOTED.

DETAILS	1/8" = 1'-0"
SECTIONS	1/4" = 1'-0"
ELEVATIONS	1/2" = 1'-0"

DATE: 01/10/00

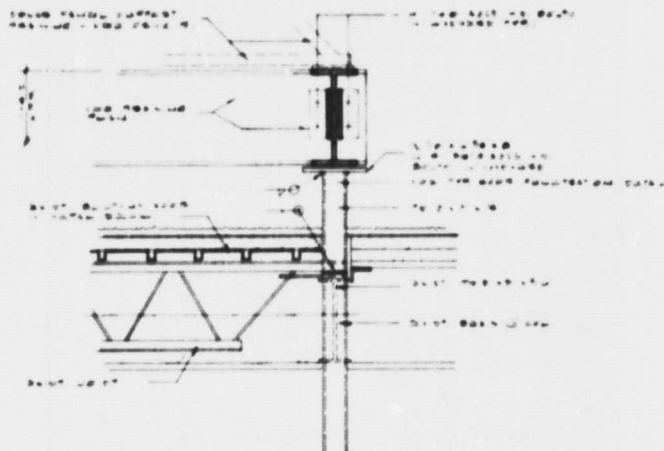
**RDA**  
RANDOLPH DESIGN ASSOCIATES  
ARCHITECTS

DAVID C. WILSON, NEUROPSYCHIATRIC HOSPITAL  
SOLAR PANEL SUPPORT FRAMING  
CHARLOTTEVILLE, VIRGINIA

DESIGNED BY: RDA  
CHECKED BY: RDA  
SCALE: 1/8" = 1'-0"  
DATE: 01/10/00  
ISSUE NO: 01  
PRINT DATE: 01/10/00  
DRAWING NO: 01

**FI**

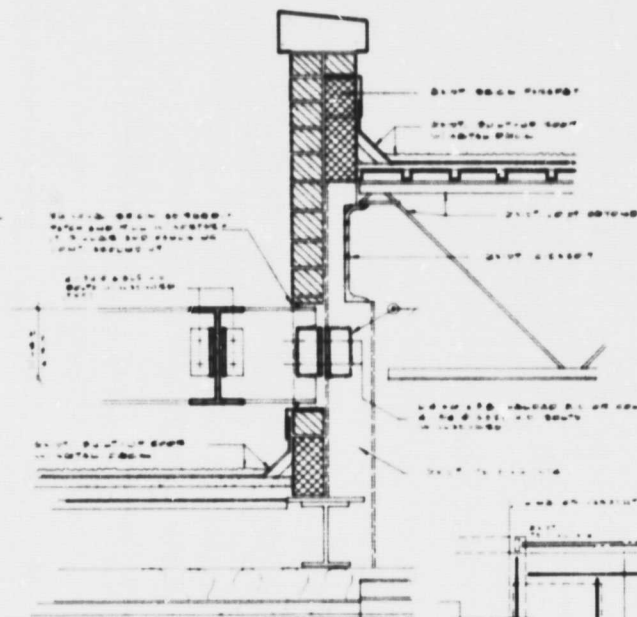
POLEOUT FRAME 2



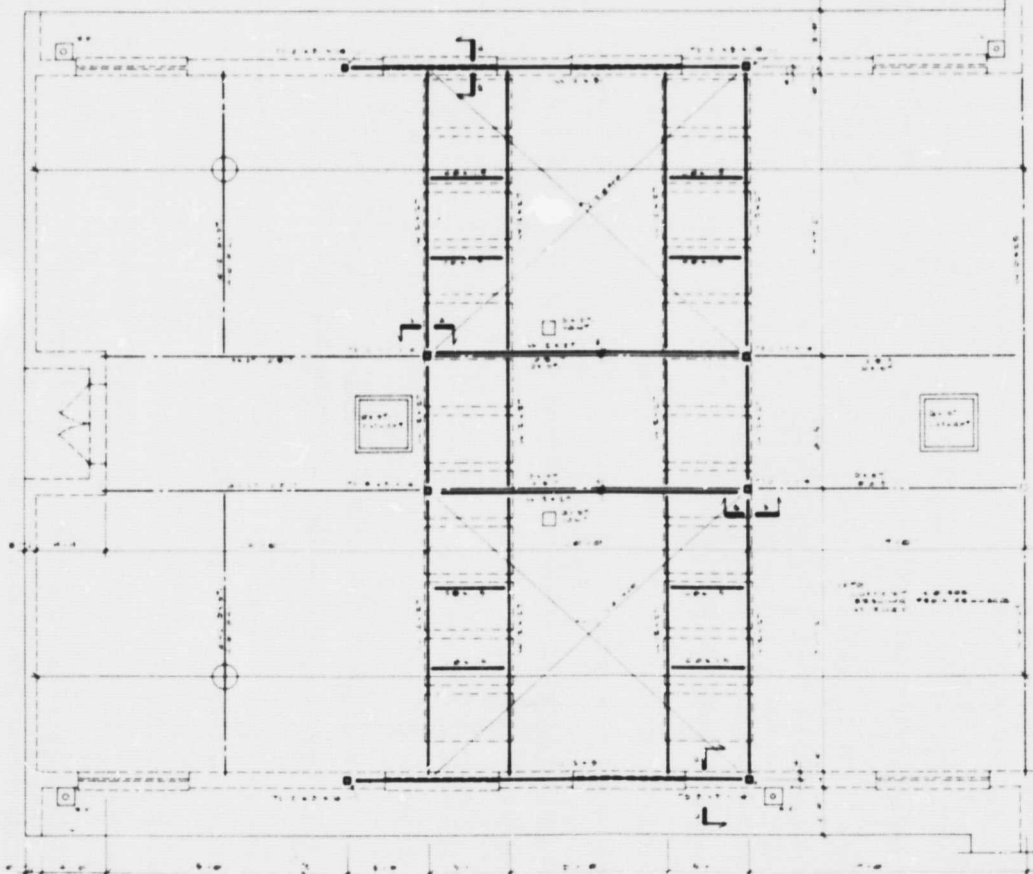
SECTION A-A

LEGEND

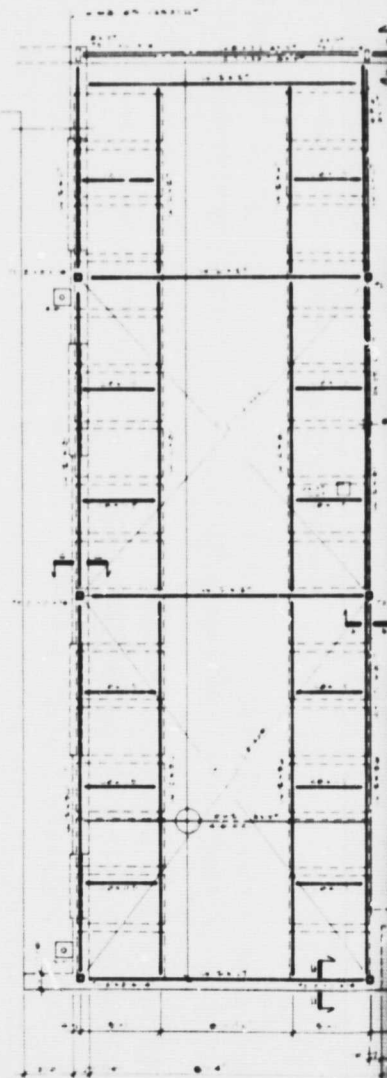
- 24\"/>



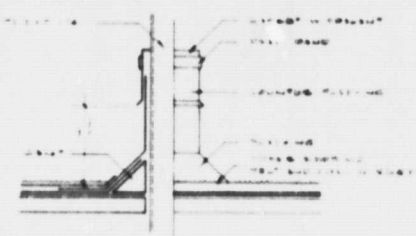
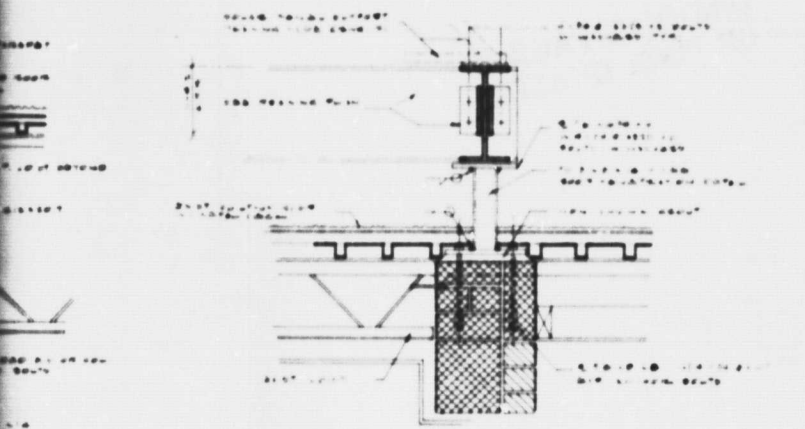
SECTION B-B



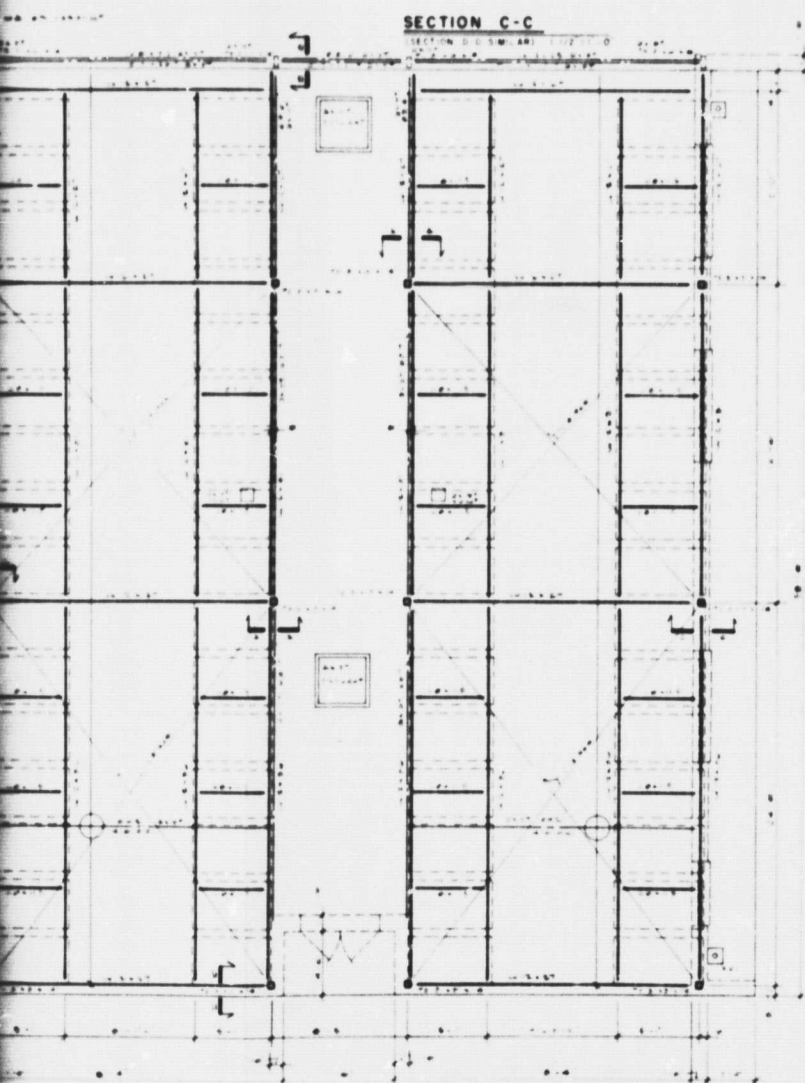
NORTH ADDITION - GRILLAGE FRAMING PLAN



WEST ADDITION



ROOF PENETRATION DETAIL



WEST ADDITION - GRILLAGE FRAMING PLAN

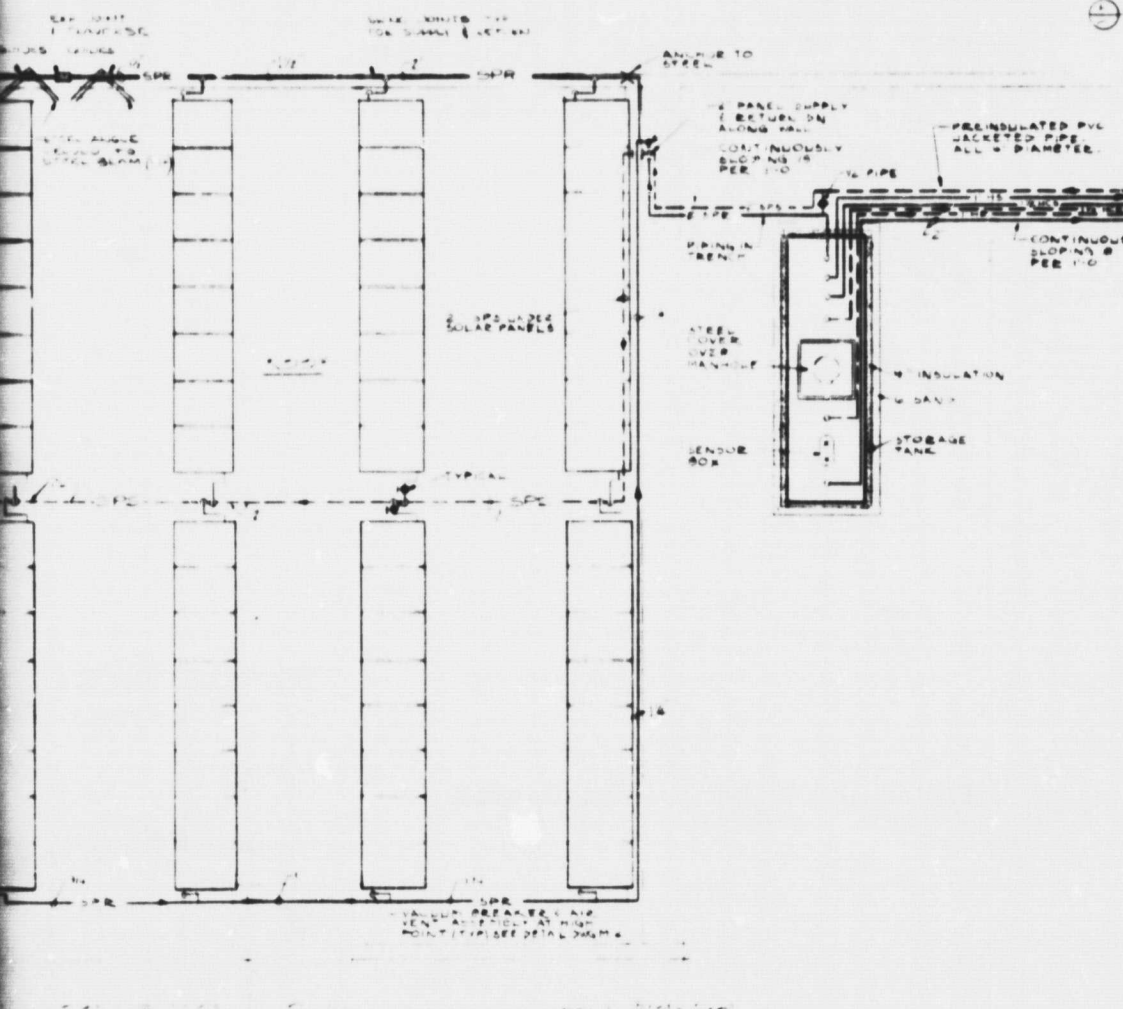
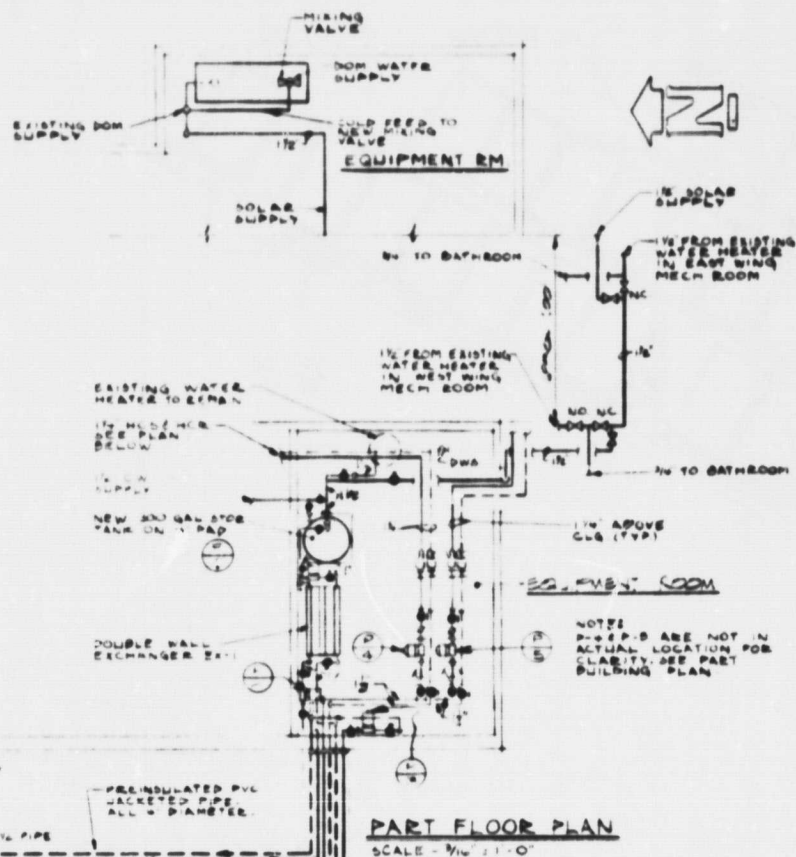
DESIGN LOADS  
20 PSF SNOW  
20 PSF WIND

REVISION DATE BY	
RANDOLPH DESIGN ASSOCIATES ARCHITECTS 1000 N. 1ST ST. CHARLOTTE, NC 28202	
PROJECT NO. 1000	DATE 10/10/99
DRAWING NO. <b>F2</b>	
PROJECT NAME DAVID C. AULSEN NEUROSCIENTIFIC HOSPITAL SOLAR PANEL GRILLAGE FRAMING CHARLOTTEVILLE, VIRGINIA	
DRAWING TITLE FRAMING PLANS, DETAILS, NOTES	
DRAWN BY RB	CHECKED BY JAT
SCALE 1/4" = 1'-0"	DATE 10/10/99
ISSUE NO. 1	PRINT DATE 10/10/99

2  
FOLDOUT FRAME





[illegible]

- [illegible]

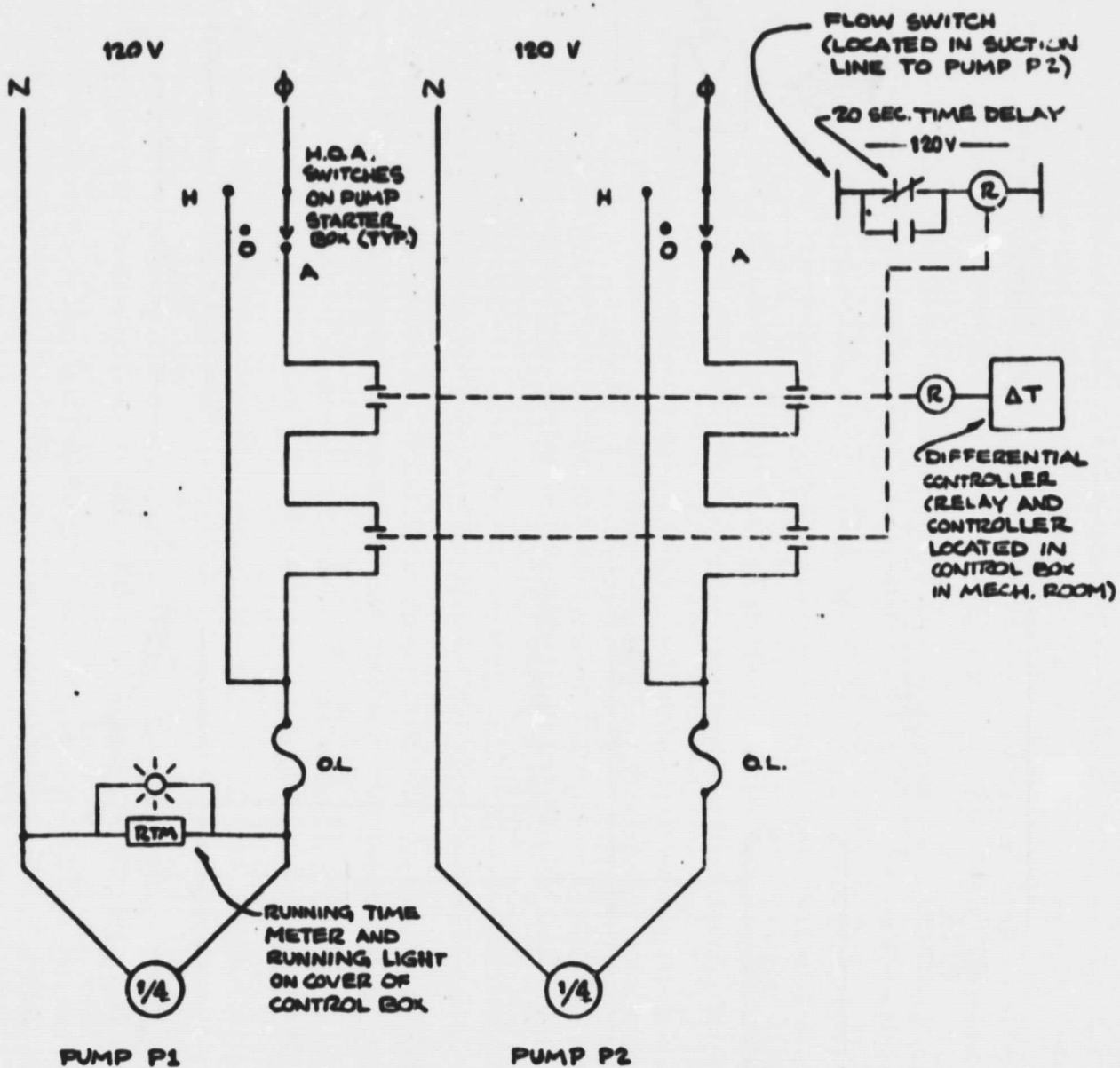
FOUND - TESTING SYSTEM - RETROFIT FOR FOUND 20.00K FOUND 20.00K FOUND 20.00K AS BUILT DRAWING		SCALE N 1/4" = 1'-0" DRAWN BY W. A. CHECKED BY N. S. JOB NO. 1561 REVISION	DATE 1-15-80 SHEET NO. 1 / 2 OF DRAWING M-1
--	--	--	---











### DOMESTIC HOT WATER CONTROL DIAGRAM

DATE:	9-10-80	DAVID C. WILSON HOSPITAL SOLAR SYSTEM RETROFIT	NUMBER:	1 OF 1
DRAWN BY:	AKC	OWEN & MAYES, INC.	SCALE:	A
APPROVED BY:		LYNCHBURG, VIRGINIA		

**PROPOSED SOLAR HEATING SYSTEM  
FOR**

**DAVID C. WILSON NEUROPSYCHIATR**

**CHARLOTTESVILLE, VIRGINIA**

**COMM. NO. 76029**

**APRIL 1978**

**OWEN & MAYES**

**LYNCHBURG, VIRGINIA**

**FOLDOUT FRAME** |



**AR HEATING SYSTEM—RETROFIT  
FOR**

**N NEUROPSYCHIATRIC HOSPITAL**

**OTTESVILLE, VIRGINIA**

**COMM. NO. 76029**

**APRIL 1978**

**OWEN & MAYES**

**LYNCHBURG, VIRGINIA**

**FOLDOUT FRAME 2**



**SET NO. 89**

# includes sheets on Addendum 02





[illegible]

DAVID C. WILSON NEUROPSYCHIATRIC HOSPITAL  
CHARLOTTESVILLE, VIRGINIA  
SOLAR HEATING SYSTEM—RETROFIT

**CONSULTING ENGINEERS** **LYNCHBURG, VIRGINIA**

1964-1965

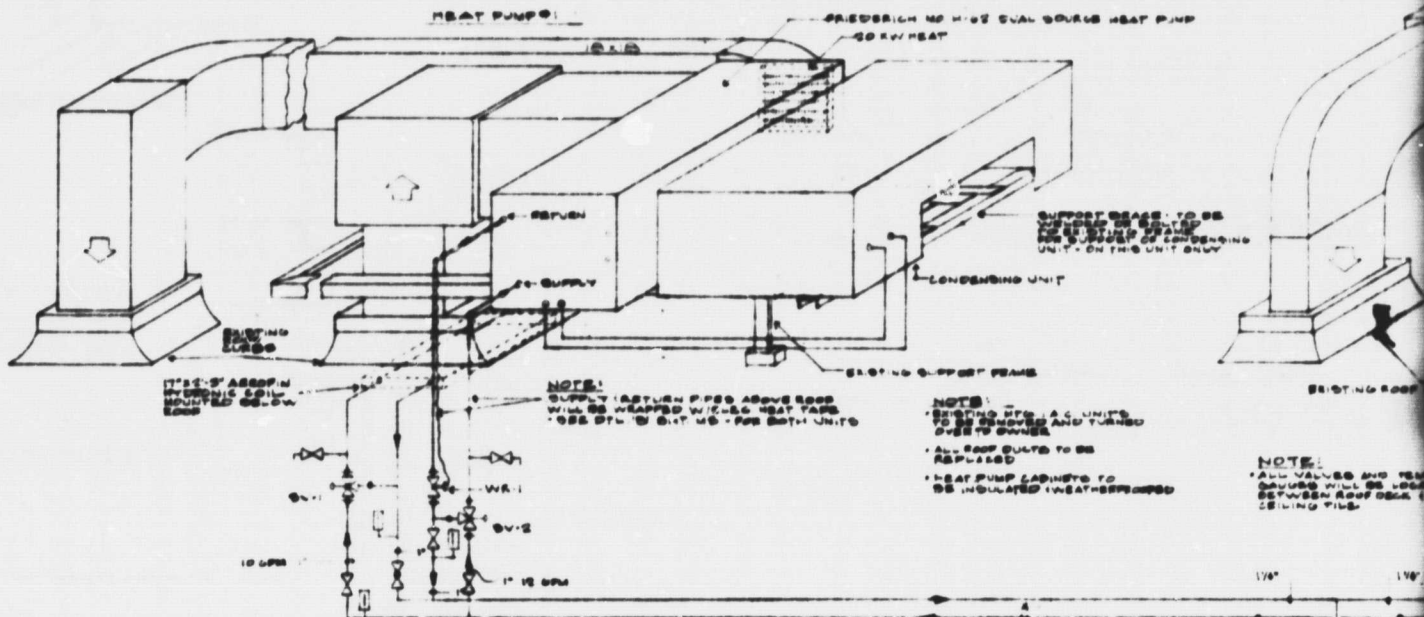
# PLAN & SECTIONS

\_\_\_\_\_

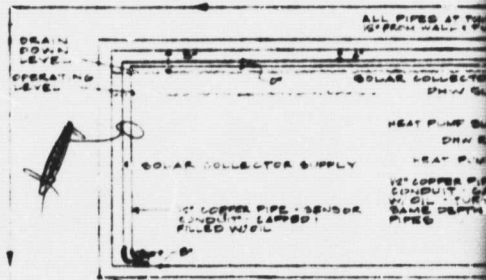
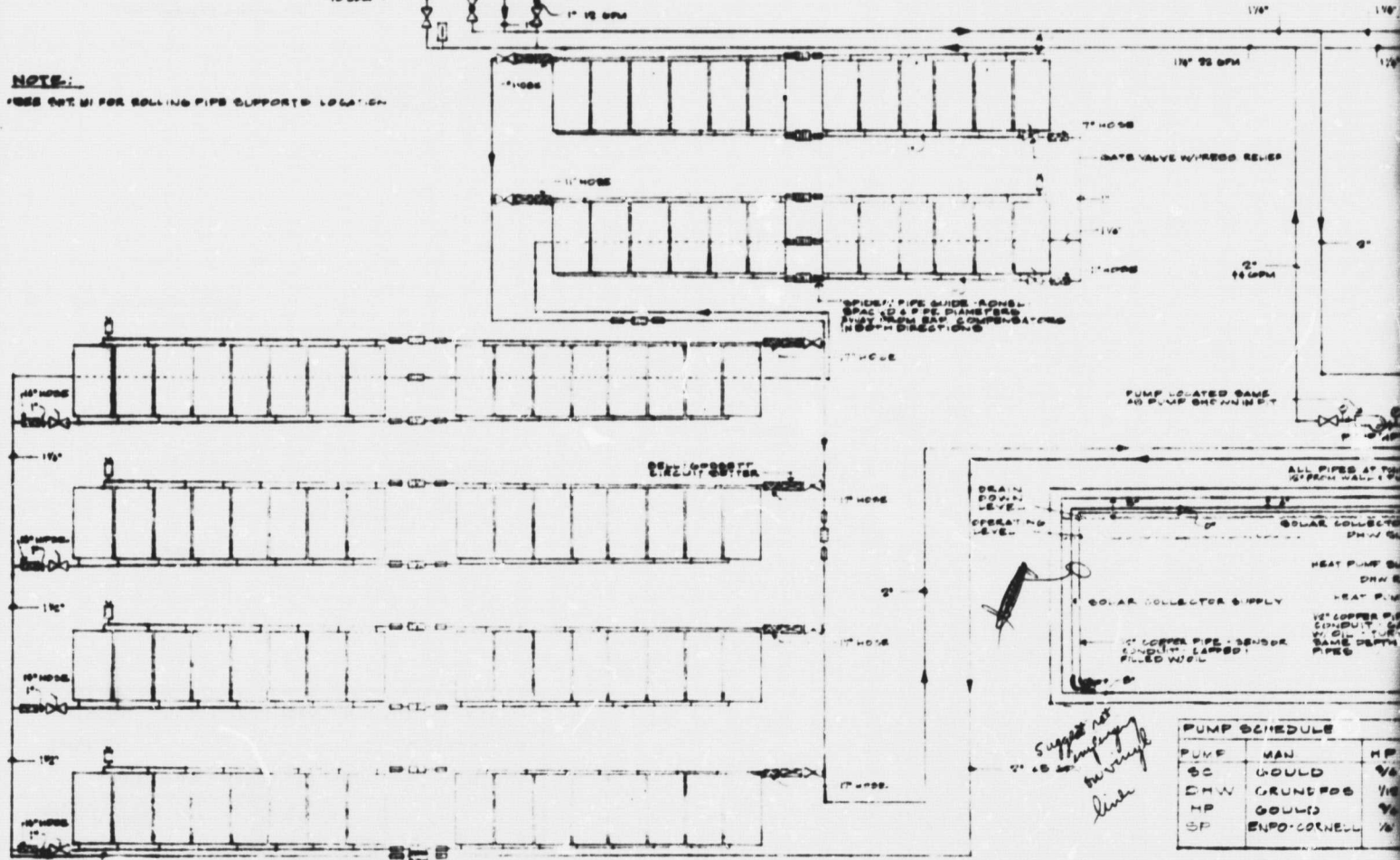
5/2/70

FOLDOUT FRAMES 2

NOTE:  
THREE ILLUSTRATIONS  
SHOW HOW THE EXISTING  
ROOF GUTTERS WILL ADAPT  
TO THE HORIZONTAL GUAL  
SOURCE HEAT PUMP



NOTE:  
SEE OUTLINE FOR SELLING PIPE SUPPORT LOCATION



*Support not  
implying  
line*

PUMP SCHEDULE		
PUMP	MAN	HP
SC	GOULD	1/2
CHW	GRUNDFOS	1/2
HP	GOULD	1/2
SP	ENPO-CORNEIL	1/2

NOTE:  
SEE OUTLINE FOR ALL TYPICAL  
PIPE SIZES

FOLDOUT FRAME



**NOTE**  
THESE ILLUSTRATIONS  
DEPICT HOW THE SAVING  
ROOF DUCTS WILL ADAPT  
TO THE HORIZONTAL DUAL  
SOURCE HEAT PUMP

## HEAT SOURCE

SUPPORT BRASS - TO BE  
WELDED OR BOLTED  
TO BRACKET OF FRAME  
FOR SUPPORT OF CONCRETE  
UNIT - ON THIS UNIT ONLY

LOADING UNIT

APPENDIX 1: PLEASE

NOTE: -  
EXISTING HFG 14C UNIT  
TO BE REMOVED AND TURNED  
OVER TO OWNER

ALL ROOF DUCTS TO BE  
REPLACED  
HEAT PUMP CABINETS TO  
BE INSULATED IN WEATHERED CASES

NOTE:  
\* ALL VALVES AND TEMP  
GAUGES WILL BE LOCATED  
BETWEEN ROOF DECK &  
CEILING FIVE

ALL INTERIOR PIPES WILL BE  
INSULATED W/ 1" ARMAFLEX

ALL TRAINERS WILL BE MOUNTED  
ON SPECIAL BOATS

PUMP ORW PUMP LOCATED CAUSE  
AS PUMP ORW IN

NOTE:  
SEE DNTMS FOR  
SPECIFIC DTLS  
REGARDING PIPE  
PUMP LOCATIONS

VACUUM BREAKER MUST BE  
- ABOVE TANK WATER LEVEL

1990

COLD WATER MAKE UP  
LINE TO HAVE REL. THE  
VALVE TO PREVENT SAG  
SIPHONING  
PUMP PUMP

NOTE:  
ALL WATER CIRCLES NO  
NEED - WILDER NO  
S BLOC - TAPE

FREEDRICH MODEL H-125 DUAL OVERBOARD HEAT PUMP  
84 MM HGT  
125 MM LGL 2100 CFM

20 KW HEAT

1- CONDENSING UNIT

HIGH LOW PRESSURE  
 PRESSURE - 100 - 150 PSI  
 AVAILABLE - ALL SOUTH UNIT

### SAVING SLIPSTY FRAMES




















TO DRUM TANKS -  
CONF. USE ONLY

SEWER INLET PIPING  
WATER TANK - BATH  
SEWER FOR OTHER  
DRY TANK W.C. IN BATH  
PLACE BUT IN BATH

DOMESTIC WATER SUPPLY

2.50 GALLON DBL V  
JACKETED DRW TAN  
FORD PROC NO 515  
ELEMENT

LEGEND:

- |   |                        |   |                              |
|---|------------------------|---|------------------------------|
|  | GATE VALVE             |  | UNION                        |
|  | GLOBE VALVE            |  | DRAIN VALVE                  |
|  | WATER REDUCING VALVE   |  | EXPANSION CONDENSATION VALVE |
|  | PEN                    |  | GATE VALVE w/PRESSURE RELIEF |
|  | BALL VALVE             |  | STRAINER                     |
|  | PRESSURE RELIEF VALVE  |  | BLOCK JUNCTION BOX           |
|  | FLOW CONTROL VALVE     |  | WATER PRESSURE GAUGE         |
|  | FLEXIBLE DRAINAGE PIPE |  | CHECK VALVE                  |
|  | VACUUM BREAKER         |  | ROUGH SPOGOT PIPE            |
|  | THERMOMETER            |   |                              |

DAVID C. WILSON    NEUROPSYCHIATRIC    HOSPITAL  
CHARLOTTESVILLE,                      VIRGINIA

## SOLAR HEATING SYSTEM — RETROFIT

OWEN & MAYES

CONSULTING ENGINEERS      LYNCHBURG, VIRGINIA

APPROVED BY \_\_\_\_\_

## PLUMBING SCHEMATIC

DATE	FILE NO.
MAY 2 1954	M 2

PUMP SCHEDULE			
PUMP	MAN	HP	VOLTAGE
GC	GOULD	7 1/2	208 V
DHW	GRUNDFOSS	7 1/2	120 V
HP	GOULD	7 1/2	208 V
SP	ENFO-CORNELL	7 1/2	20 V

NOTE:

USE BRONZED BRASS FOR  
GASKETS IN ALL JOINTS  
JACKET PIPE NOT USED  
FLASHING

FLASHING - POLYMER - FLASHING  
SE - END FOR FLASHING - FLASHING  
SEALANT - SEALANT  
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NOTE:  
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V.D.

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NOTE: TO BE USED OVER ALL  
BACKFILL



10 HOLES IN F.W. WOOD FOR  
LINES TO DRAW - 2 TO - 5  
F.W. SYSTEM - 2 TO - 5  
IN CONDUITS

A  
V.D.

FOLDOUT FRAME

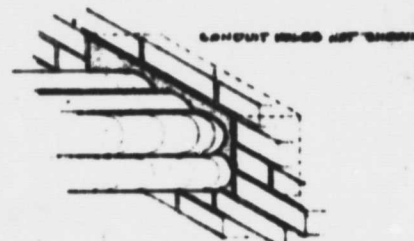
NOTE:  
CONTRACTOR TO CO-  
ORDINATE WITH OWNER  
FOR SUBC. CONDUIT

CONDUIT RISER



WALL PLATE ELEVATION

SCALE 1/8\"/>



TYPICAL PIPE ARRAY TO WALL

M.S.

NOTE:  
SPL. CASE FOR RETURN LINE -  
SEE SECTION ABOVE

HEAT TAPS - WRAPPED  
TIGHTLY AND NO TAPER

HEAT PUMP

PIPE HEAT TAPS WRAPPED  
BY THERMOPLEX INS. &  
ASBESTOS FIBER GLASS  
IS COATED LATER PAINT

DATA - P. 100 P. 110  
ASBESTOS FIBER GLASS

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PER JACKET OR  
ADAPLUSTING

GRADE

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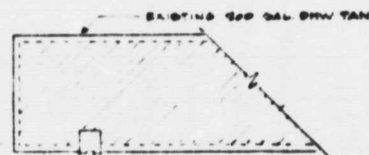
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PIPE THROUGH WALL DETL

SCALE 1/8\"/>



DETAIL DRW'G

DAVID C. WILSON NEUROPSYCHIATRIC HOSPITAL  
CHARLOTTESVILLE, VIRGINIA  
SOLAR HEATING SYSTEM - RETROFIT

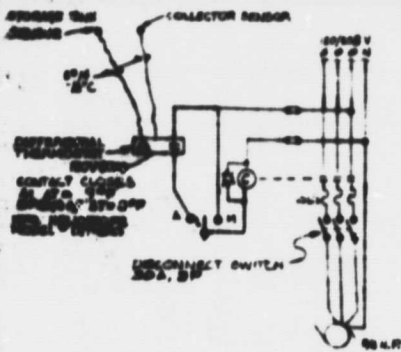
OWEN & MAYES

CONSULTING ENGINEERS LYNDENBURG, VIRGINIA

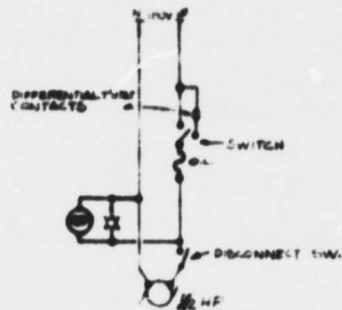
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DETAILS

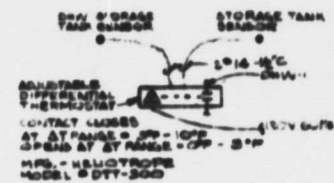
BY: M.S.



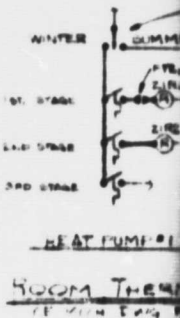
**PUMP SC**  
(SOLAR COLLECTOR CIRCULATION PUMP)



**PUMP DHW**  
(DOMESTIC HOT WATER CIRCULATION PUMP)

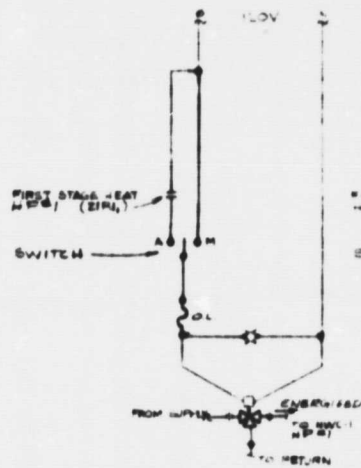


**CONTROL DIAGRAM OF DHW PUMPS**

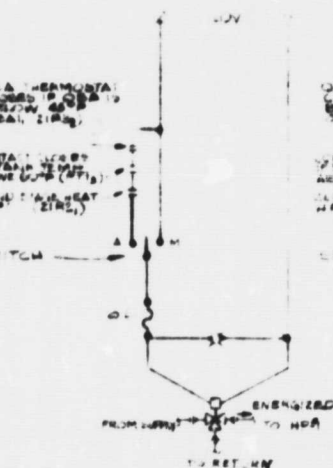
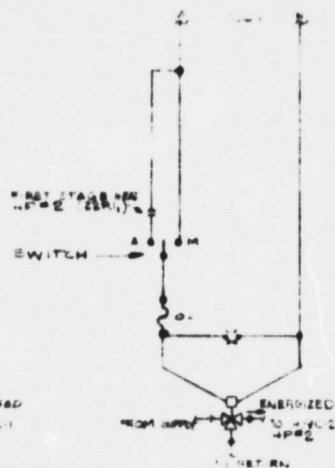


**HEAT PUMP**

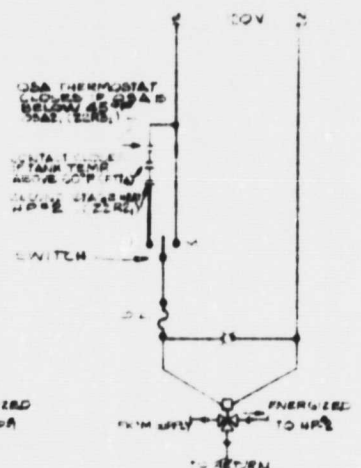
**ROOM THERM**



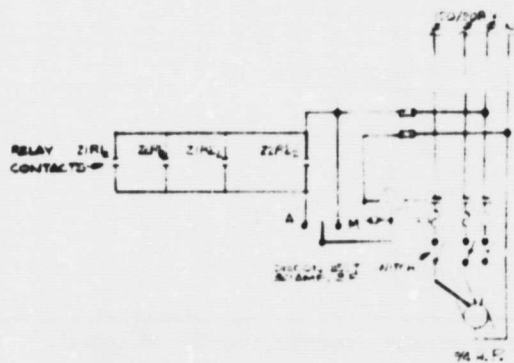
**SOLENOID SV-1**  
(HOT WATER COIL SOLENOID VALVES FOR HEAT PUMPS NO. 1 & 2)



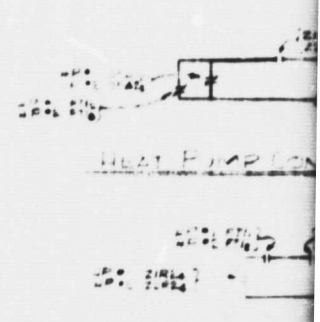
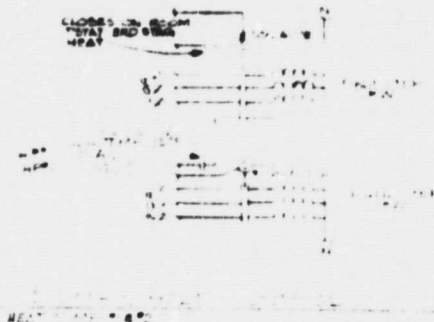
**SOLENOID SV-3**  
(REFRIGERANT HEAT EXCHANGER SOLENOID VALVES FOR HEAT PUMPS NO. 1 & 2)



**SOLENOID SV-4**  
(REFRIGERANT HEAT EXCHANGER SOLENOID VALVES FOR HEAT PUMPS NO. 1 & 2)



**PUMP HWP**  
(HOT WATER SUPPLY PUMP)



**FOLDOUT FRAME**

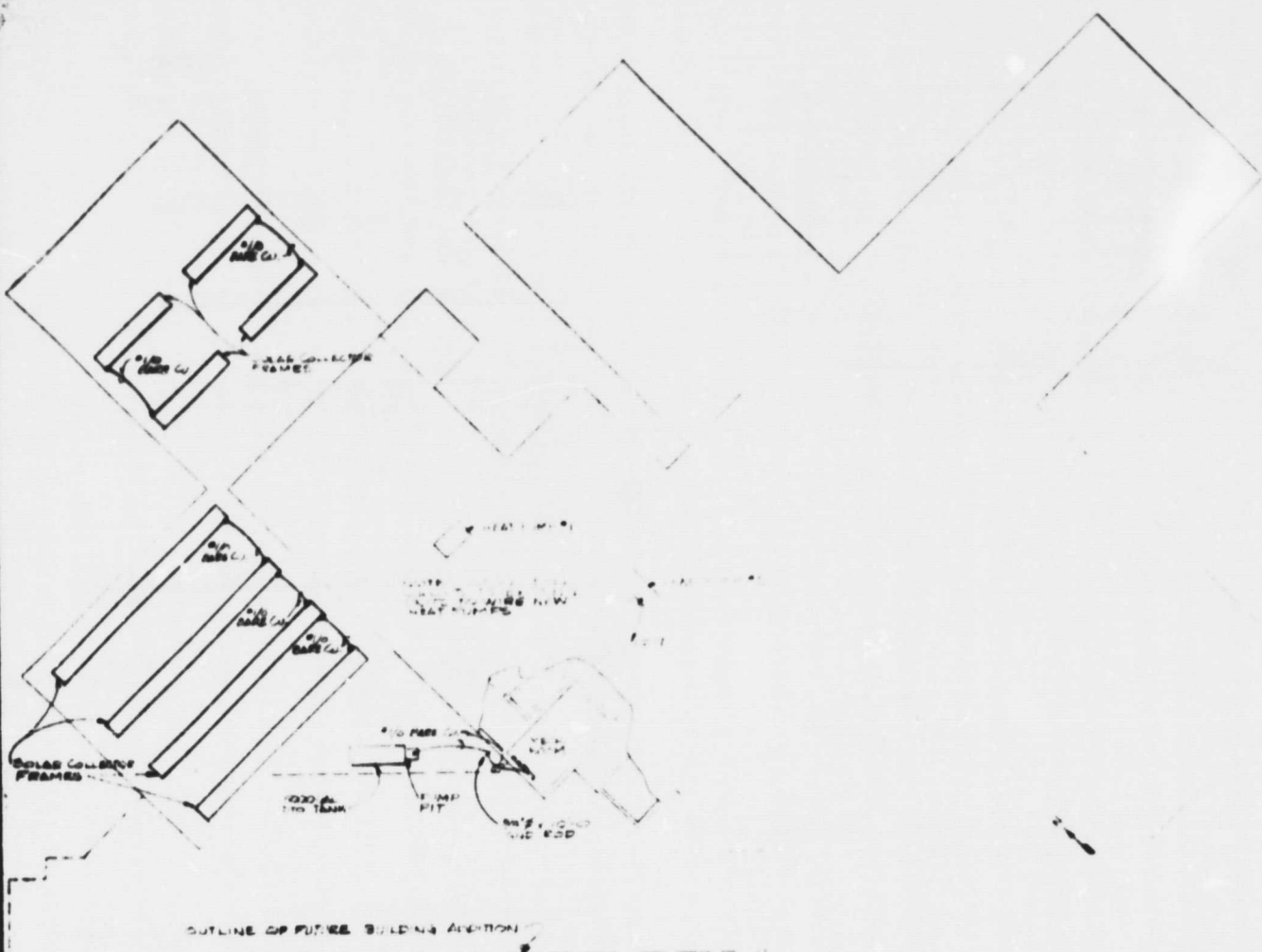




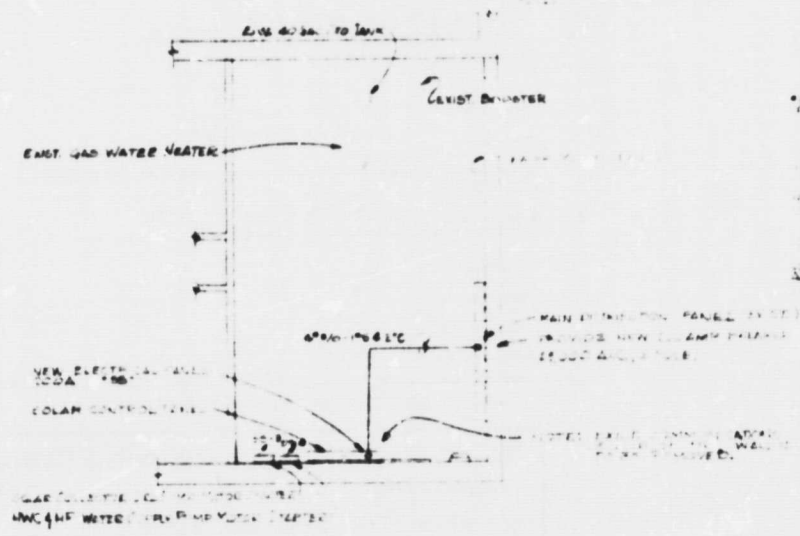


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B-13

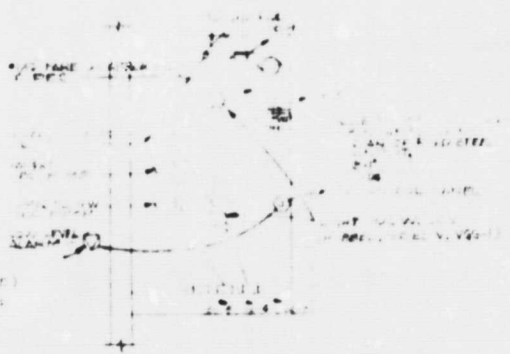


SITE PLAN



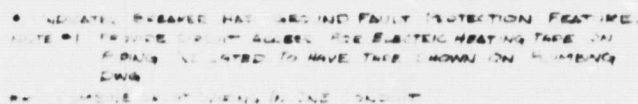
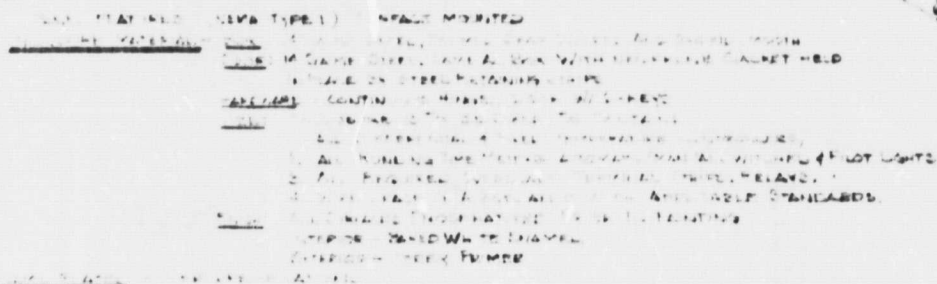
MECHANICAL ROOM FLOOR PLAN

1/1/5



PUMP PIT FLOOR PLAN

**FOLDOUT FRAME**



ABBREVIATIONS		RTM	RUNNING TIME MATER
MECH	MECHANICAL		
GRND	GROUND		
EXIST	EXISTING		
REG	REGULATION		
HEAT	HEAT		
HW	HOT WATER COIL		
HP	HORSE POWER		
HE	HORIZONTAL		
EQ	EQUIPMENT		
NT	NORTH TOWARD		
CT	COLD TOWARD		
DR	DISCHARGE		
MG	MAGNET ONLY		
INT	INTERESTING FACTS		
HW	HOT WATER		
WT	WITH		
FEET	FEET TO COMPLETION		
STO	STORAGE		
CTR	CENTER		
PR	POWER		
N	NEUTRAL		
OL	OVER LOAD		
DT	DIFFERENTIAL TEMPERATURE		
A	AUTOMATIC		
M	MANUAL		
COL	COLD AIR		
F	FORES		
KW	KILOWATT		

FOLDOUT FRAME 2

DAVID C. WILSON NEUROPSYCHIATRIC HOSPITAL  
CHARLOTTESVILLE, VIRGINIA  
SOLAR HEATING SYSTEM - RETROFIT

OWEN & MAYES

CONSULTING ENGINEERS LYNCHBURG, VIRGINIA

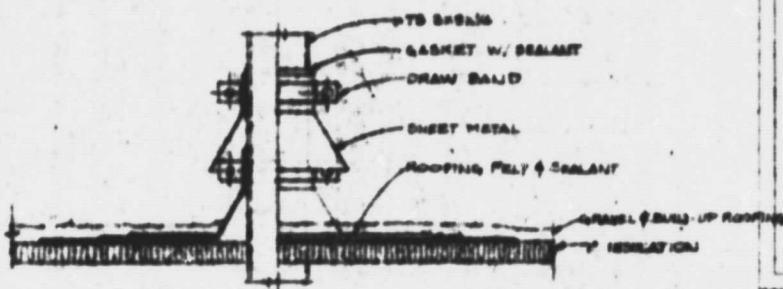
REAL NONE APPROVED BY

4-7-78

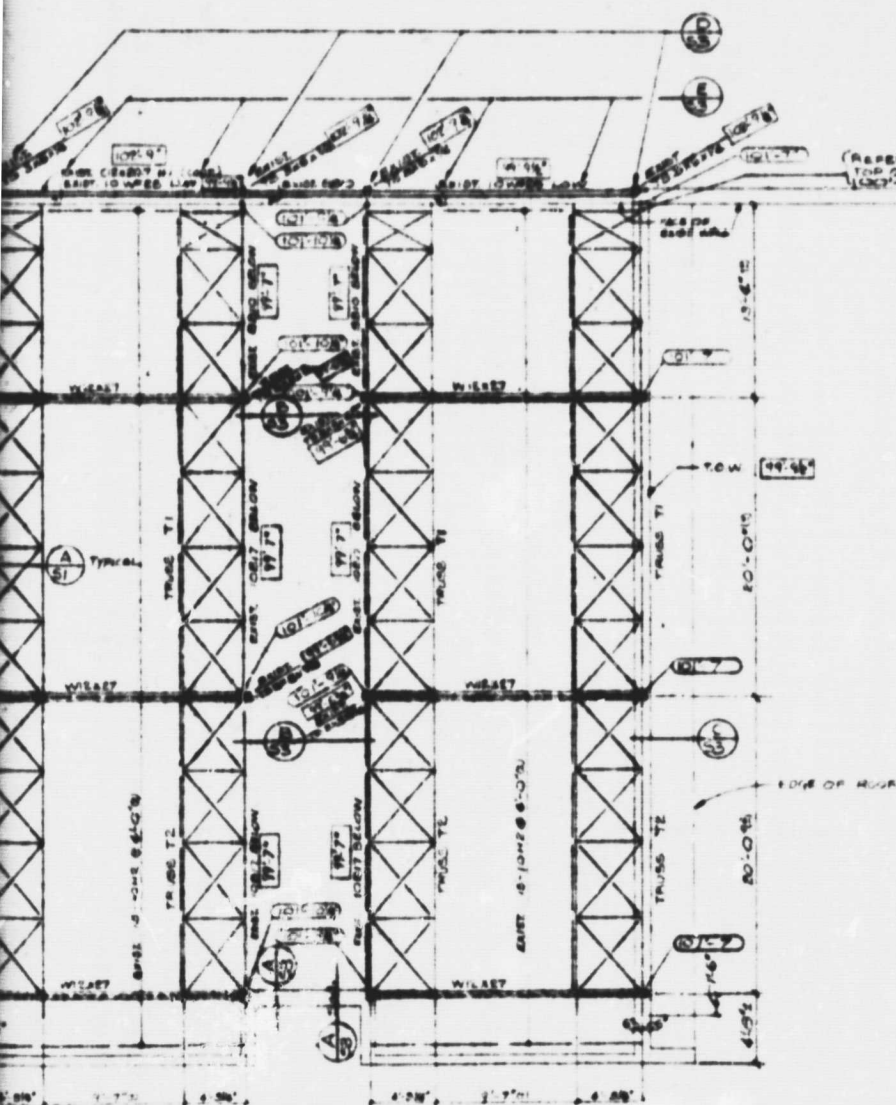
ELECTRICAL PLANS, SCHEDULE A

E 2





TYPICAL ROOF PENETRATION  
NTS.



#### NOTES

1. FIELD VERIFY ELEVATIONS & DIMENSIONS PRIOR TO FABRICATION.
2. WELDING: TRUSS - FULL DEPTH PENETRATION OR 1/8" MIN. AS REQUIRED  
FIELD - FULL DEPTH PENETRATION  
ELECTRODE - E70XX
3. FIELD WELD ALL 2" X 1/4" TO TRUSS TO SUPPORT PIPING
4.    - INDICATES EXISTING REFERENCE ELEVATION BASED ON DESIGN DRAWINGS OF EXISTING ADDITION.  
PREPARED BY THOMAS R. WYANT JR. ARCHITECT 18 APRIL 1988

#### DESIGN LIVE LOADS

ROOF WITH SOLAR COLLECTORS 10 PSF  
WIND 20 PSF

#### ABBREVIATIONS

T.O.W.	TOP OF WALL
ELEV.	ELEVATION
EXIST.	EXISTING
CONT.	CONTINUOUS
W/	WITH
NTS.	NOT TO SCALE
EQ.	EQUAL
UNO.	UNLESS NOTED OTHERWISE
P.	PLATE

DAVID C. WILSON NEUROPSYCHIATRIC HOSPITAL  
CHARLOTTESVILLE, VIRGINIA

SOLAR HEATING SYSTEM - RETROFIT

**OWEN & MAYES**

CONSULTING ENGINEERS

1000 N. 10TH ST.

CHARLOTTE, NC 28202

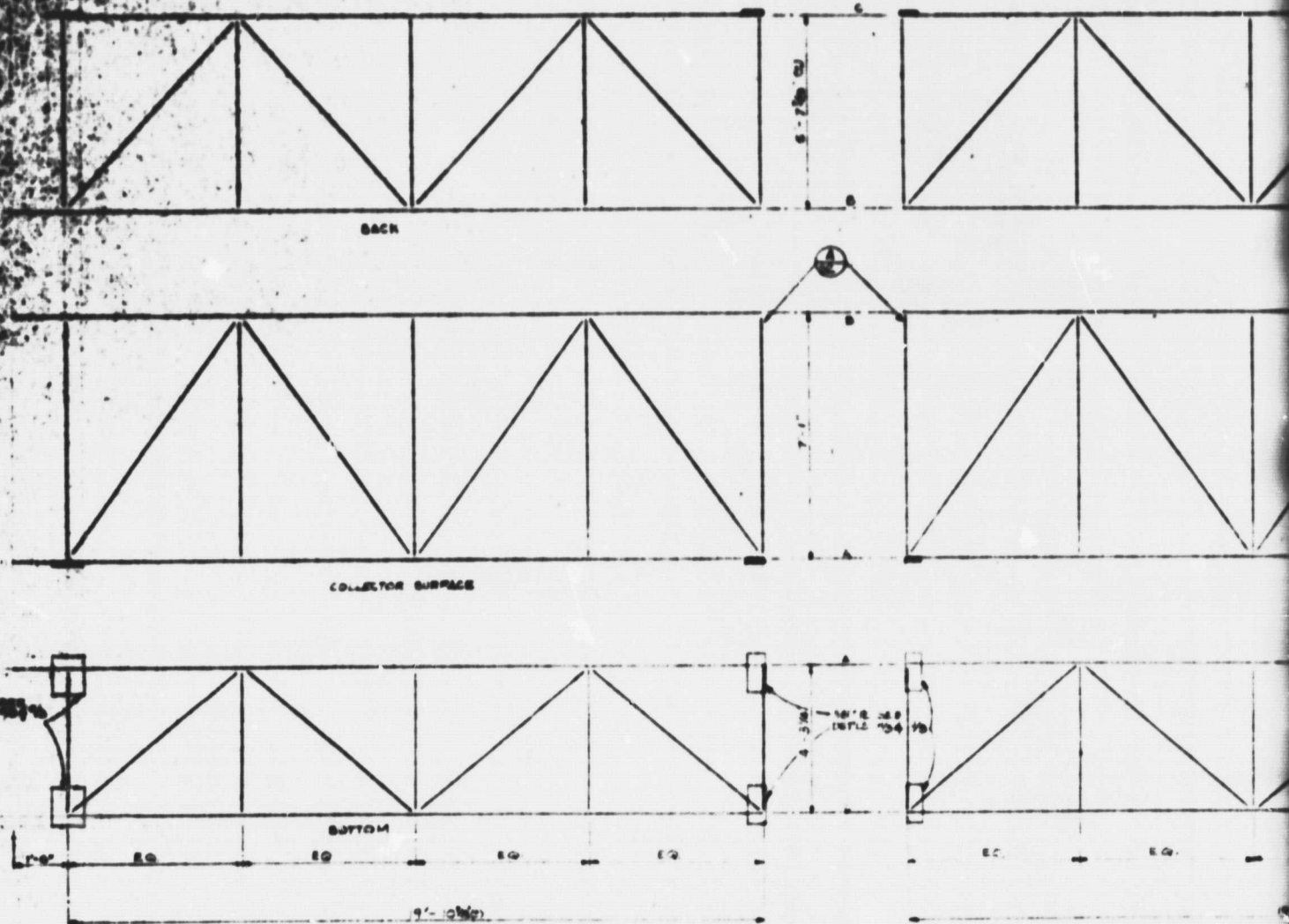
COLLECTOR SUPPORT SYSTEM PLAN



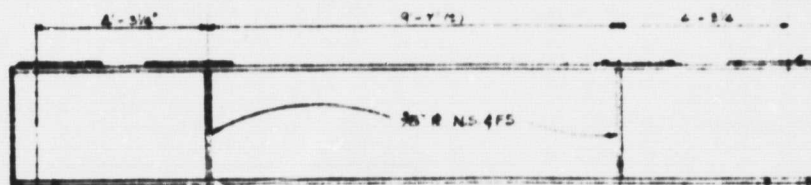
FOLDOUT FRAME

2





TRUSS T2

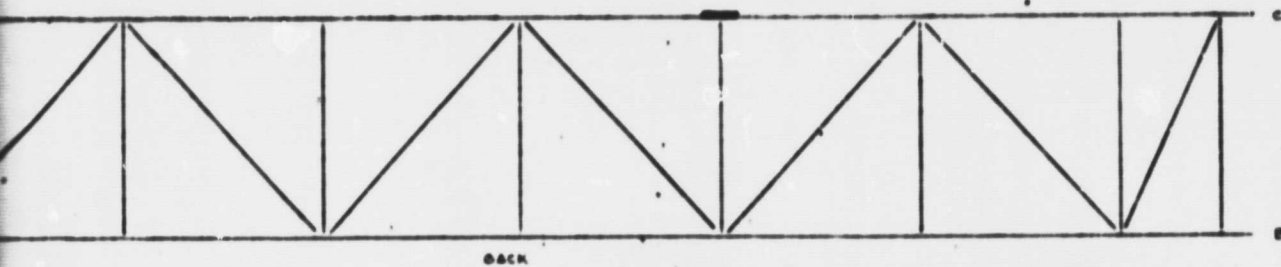


BEAM W12x27

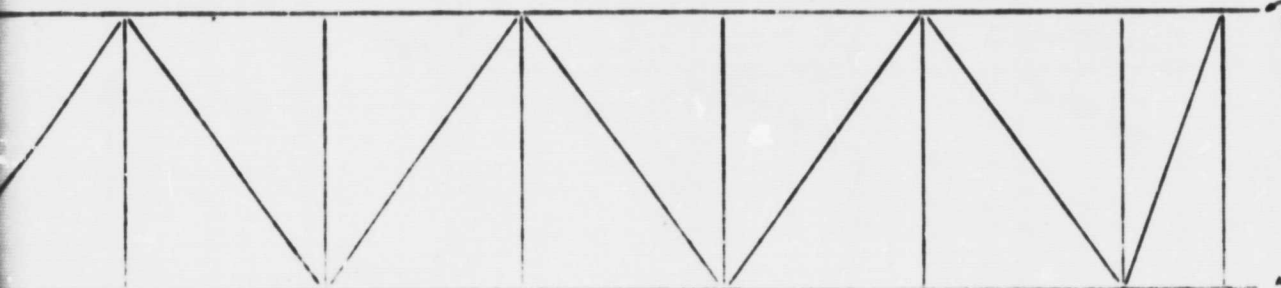
FOLDOUT FRAME



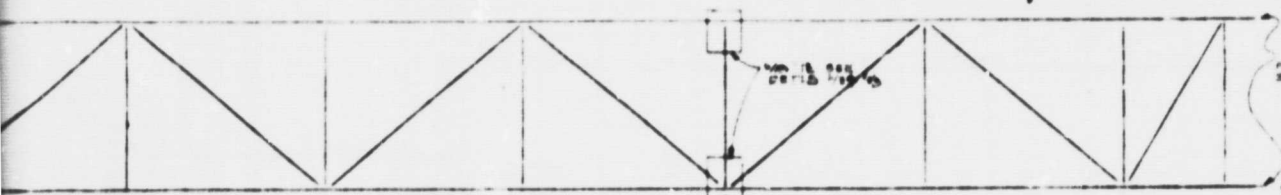
TRUSS T2



BACK



CELLS FOR INSULATION



BOTTOM

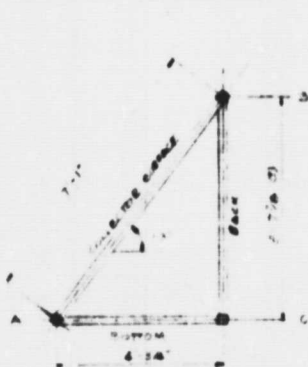


9'-0" (3)

13'-4" (3)

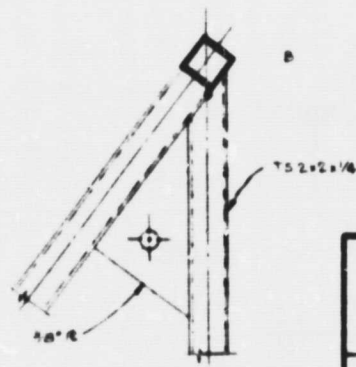
FIELD VARYING DIMENSIONS PRIOR TO TRUSS FABRICATION

TRUSS T1



TYP. TRUSS SECTION

NTS



DETAIL

SCALE 3/4"=1'-0"

2

FOLDOUT FRAME

DAVID C. WILSON NEUROPSYCHIATRIC HOSPITAL  
CHARLOTTESVILLE, VIRGINIA  
SOLAR HEATING SYSTEM—RETROFIT



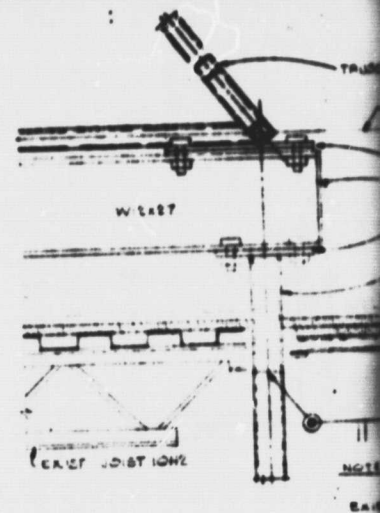
OWEN & MAYES

CONSULTING ENGINEERS

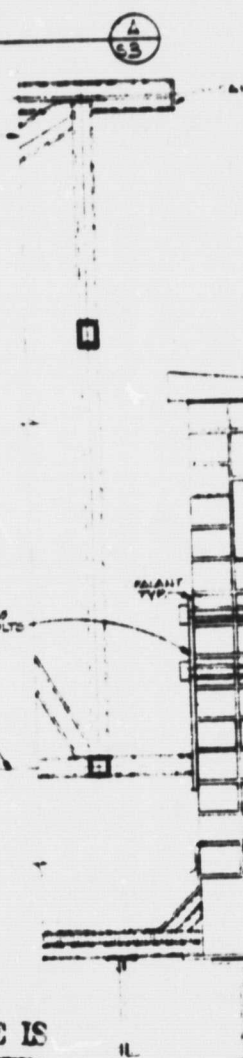
MEMBER ASHRAE

TRUSS T1 & T2 AND BEAM

15

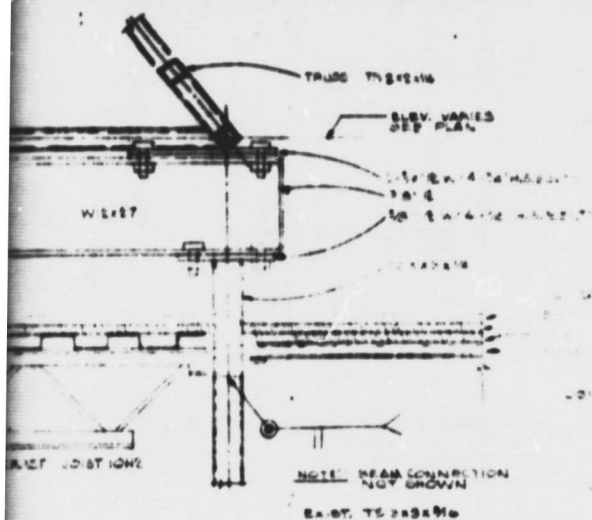


## DETAIL

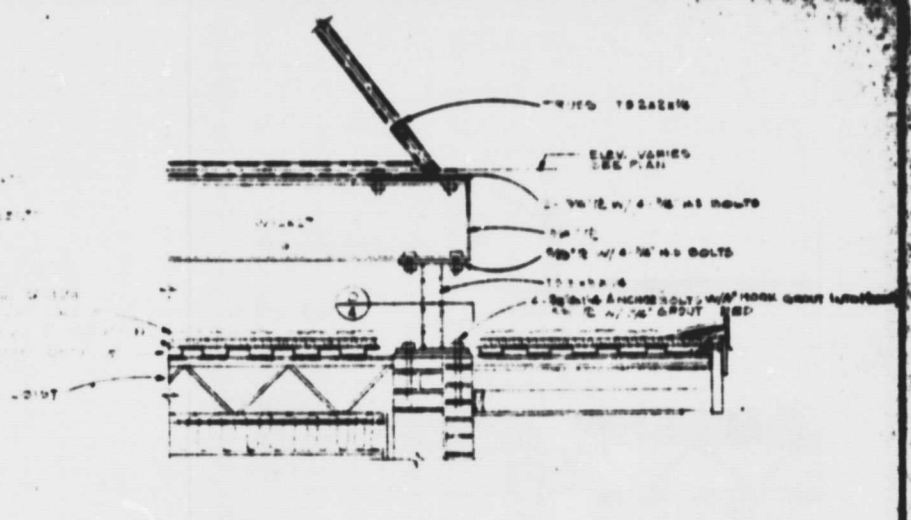


ORIGINAL PAGE IS  
OF POOR QUALITY

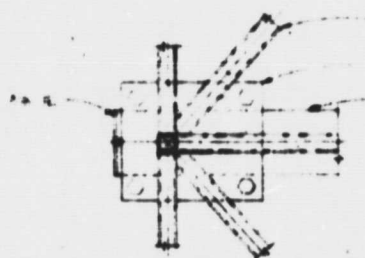
DETAIL



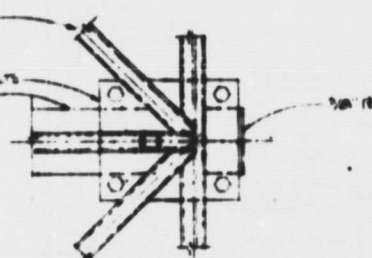
DETAIL B



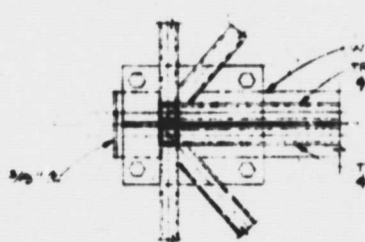
DETAIL C  
SCALE 1" = 10'



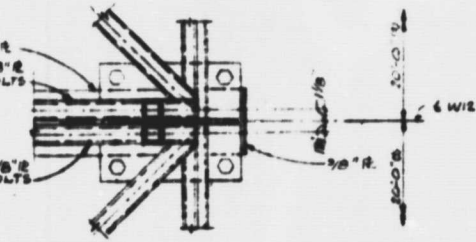
DETAIL F



DETAIL G

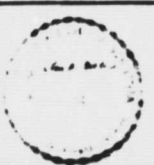


DETAIL H



DETAIL J

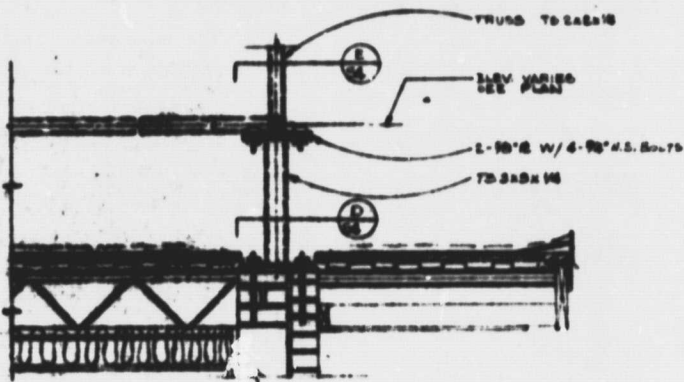
DAVID C. WILSON NEUROPSYCHIATRIC HOSPITAL  
CHARLOTTESVILLE, VIRGINIA  
SOLAR HEATING SYSTEM — RETROFIT



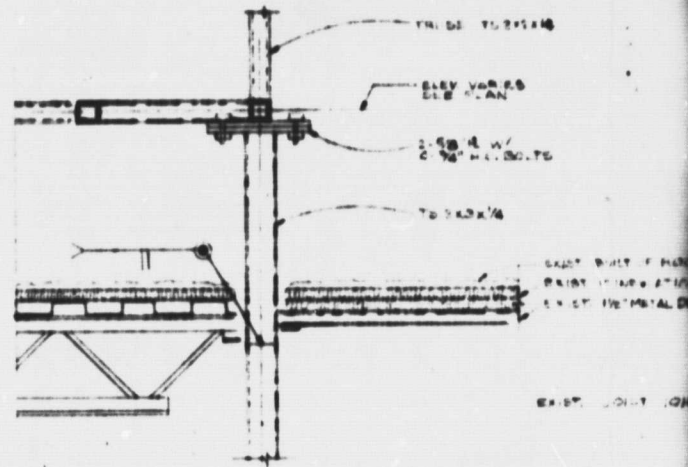
OWEN & MAYES

CONSULTING ENGINEERS  
MEMBER A.S.C.E.  
4-7-78  
TRUSS T1 & T2 AND BEAM DETAILS

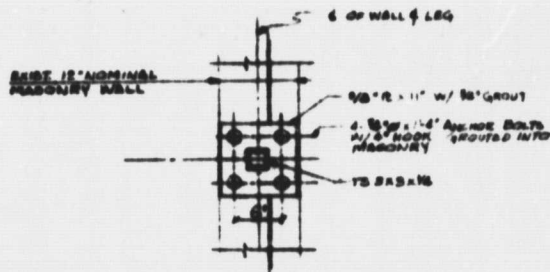




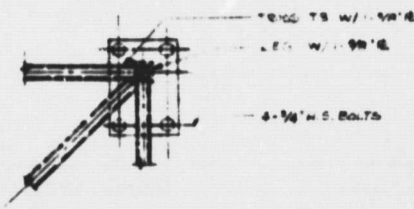
DETAIL  
SCALE 1"=1'-0"



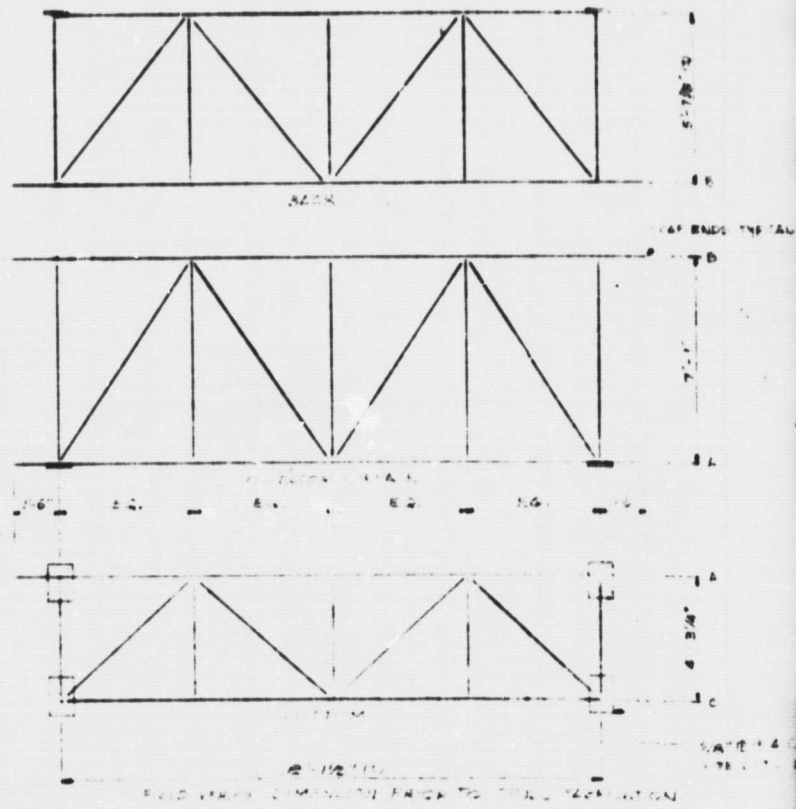
DETAIL  
SCALE 1"=1'-0"



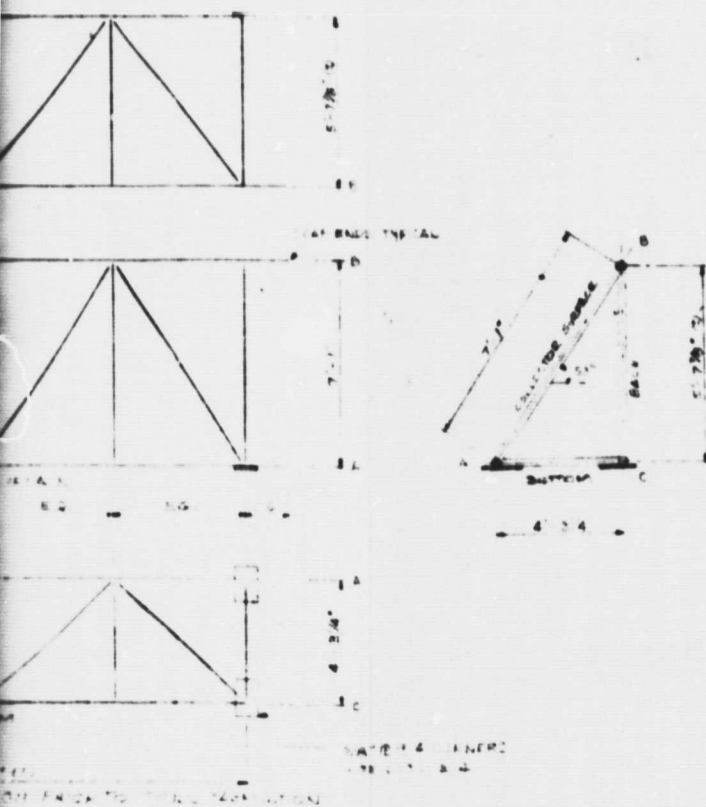
DETAIL  
N.T.S.



DETAIL



FOLDOUT FRAME



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**FOLDOUT FRAME**